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AN INVESTIGATION INTO THE POTENTIAL LOSSES OF FISH ON THE FILTER PLATES, AT THE

HODDER WATER TREATMENT WORKS STOCKS RESERVOIR.

Scientific Investigations Database - NFTT

Unique Document No: 5186

UDC Class No: 639.2.053.3

Keywords: ENTRAINMENT, SECTION 14, MORTALITY

Annotations:

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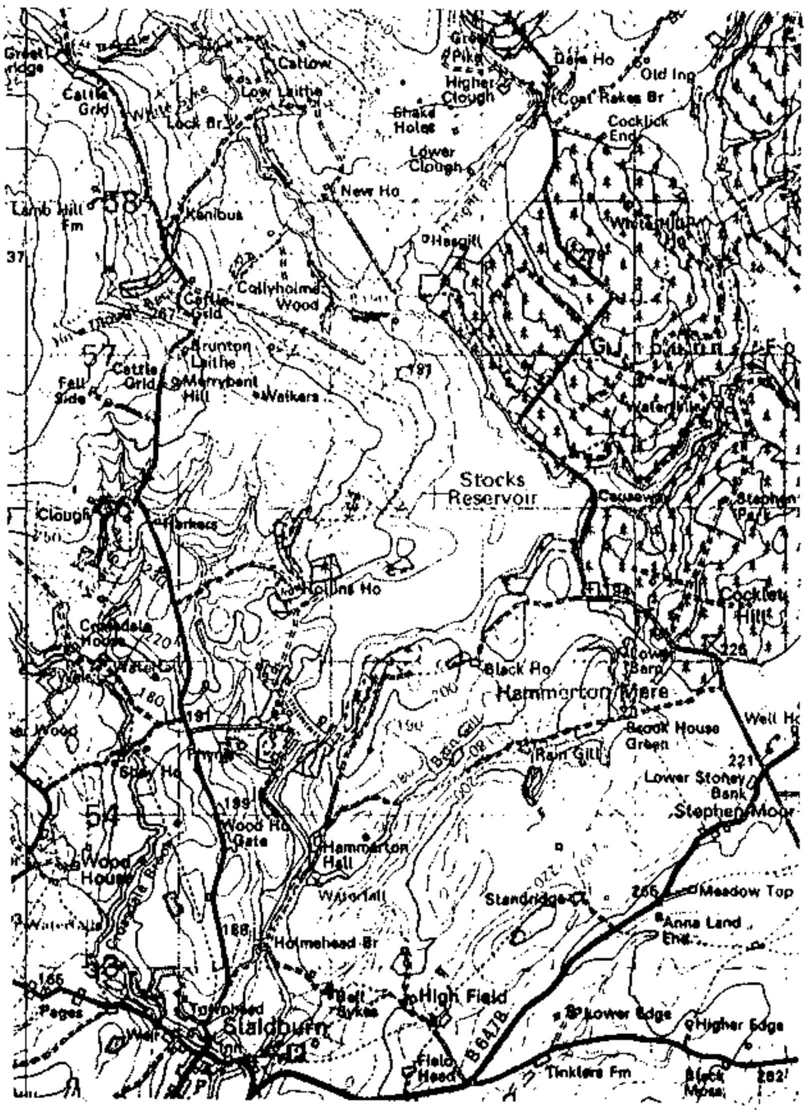
FISHERIES SECTION
RIVERS DIVISION

North West Water

NOVEMBER 1984

AN INVESTIGATION INTO THE POTENTIAL LOSSES OF FISH ON THE FILTER PLATES AT THE HODDER WATER TREATMENT WORKS, STOCKS RESERVOIR.



Stocks Reservoir is situated amidst the Forest of Bowland in the upper reaches of the old river valley of the Hodder. Located about 10 miles due North of Clitheroe its altitude is only 100 metres higher than that of this Lancashire market town. The water levels altitude of 180 metres is not unduly high compared with other Pennine Reservoirs but the upland catchment of moorland, reaching to over 500 m gives the reservoir truly oligotrophic characteristics.

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The reservoir was built in 1927 for the Fylde Water Board who primarily supplied water to Blackpool. The catchment of 9283 acres was initially controlled by the board, and more recently by the Water Authority, the practices of which will not have unduly altered the water chemistry of the reservoir. Moorland sheep grazing predominates, the peaty land producing a pH of around neutral whilst the peaty colour of the water shows the humic acid presence, readily seen in the fairly high hazen readings. The upland catchment is characteristically nutrient poor giving the reservoir it's oligotrophic status with fish food organisms in the static waters of the reservoir rather limited. However, prior to the construction of the earthen dam the River Hodder's upper reaches were annually populated with salmon and sea trout spawning on the riffles. The quality of the riverine salmonid production, upstream of the reservoir, was of such value that when the dam was proposed, compensation for loss of fish spawning was made by way of constructing Dunsop Fish Farm for the Board of Conservators. Natural trout spawning still exists in the Hodder headwaters and the extent of this will be seen in this report, reflecting the quality of wild brown trout in the reservoir.

Additionally, the innate migration of trout still possibly exists in the native stock because a number of sea trout must have been land locked by the construction of the dam. There is believed to be a smolt migration downstream from the reservoir in the spring of each year and a behavioural characteristic of brown trout, as opposed to rainbow trout, causes the treatment plant to catch fish on their intake screens throughout the year.

The water treatment plant situated below Stocks Dam can filter and treat 115 Ml of water per day. Water is taken from the reservoir by way of a draw off tower (Diagram 1) situated 200 feet out from the top level on the dam wall. The draw off tower has three 24" draw off ports each controlled by 2 X 21" valves. At any one time one or more, usually two, of these ports are open, allowing water and whatever is carried in suspension, through the 24" apertures into a 33" collecting main that delivers the water to the filter house. The supply is then divided into 3, flowing under pressure to three groups of batteries of filters, but prior to the water entering the rapid sand filters each supply goes through a screen called a fish plate. These fish plates are an original design structure (to be described later) and this nomenclature implies that the treatment plant, design correctly, allowed for the ingress of fish into the works. As opposed to other water intake structures that have screens to prevent initial ingress of any foreign body, or off line low pressure screens, Stocks has these on line pressurised screens called fish plates.

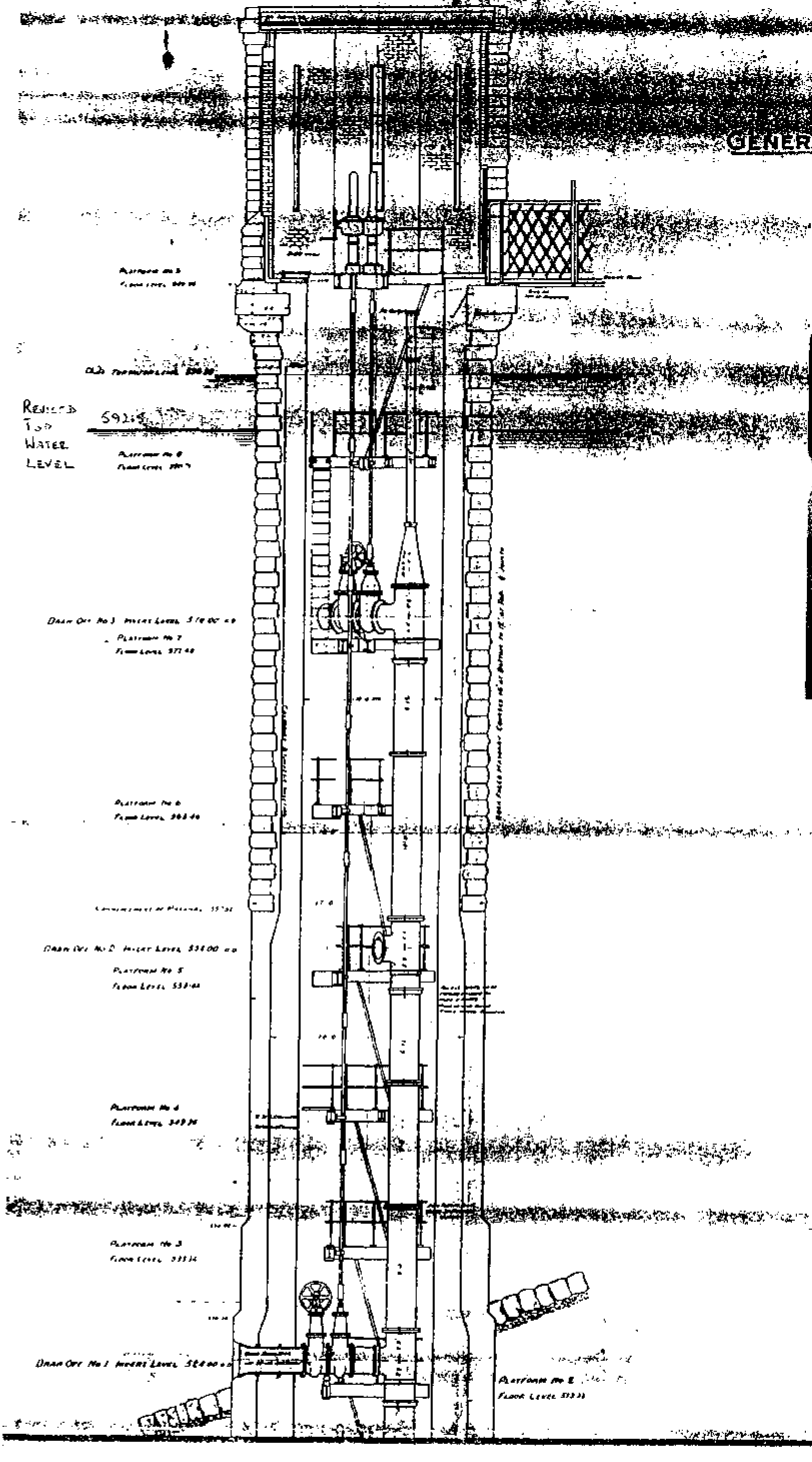
FYLDE WATER BOARD

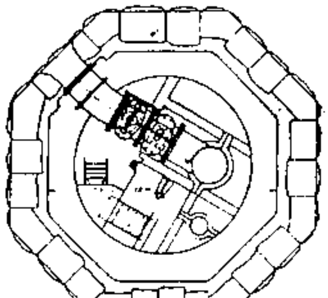
STOCKS RESE

DIAGRAM 1.

VALVE TOWER

GENERAL ARRANGEMENT, SCAL





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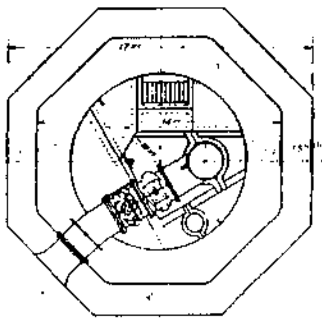

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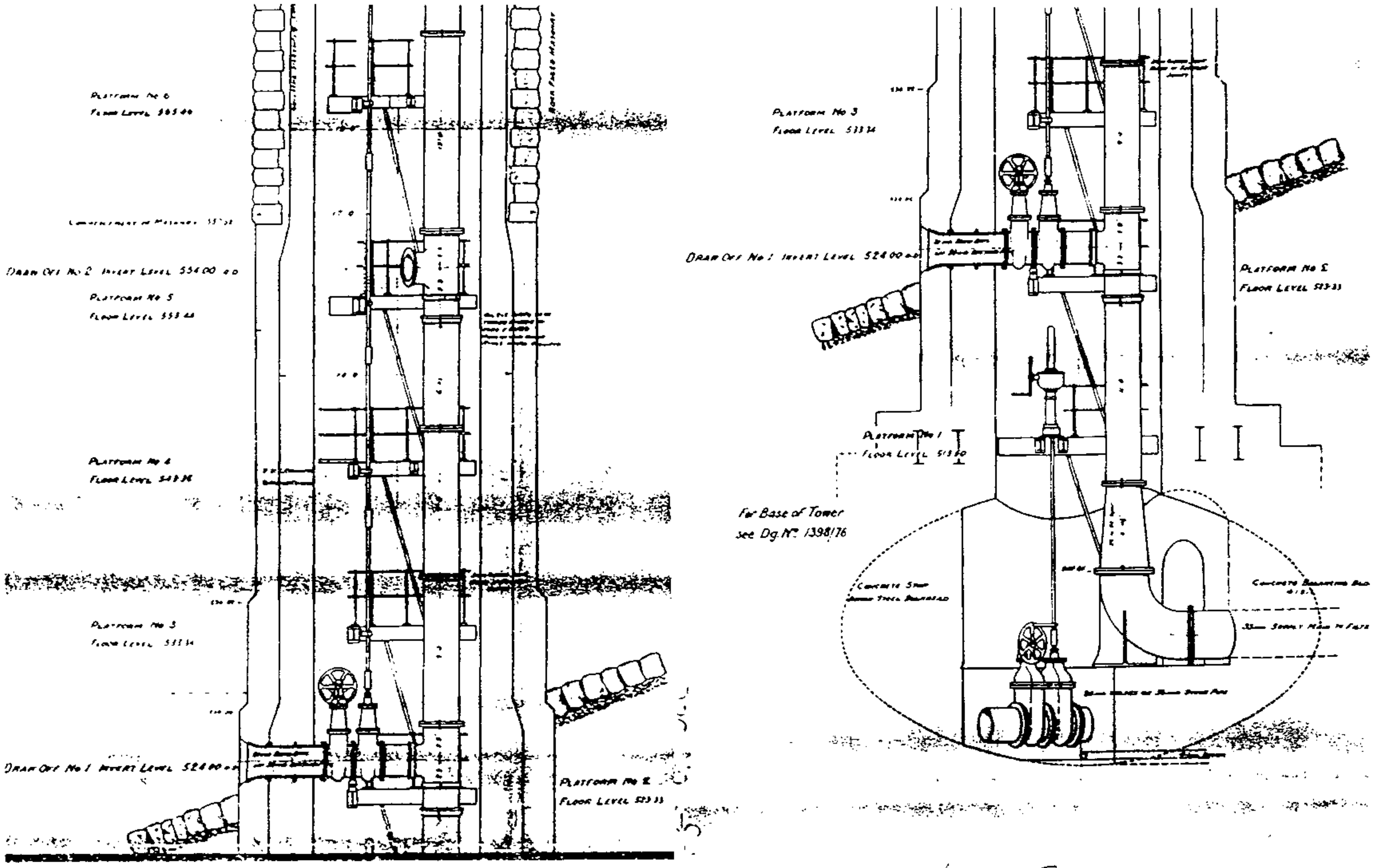


Diagram 1A.

Plan of Valve Tower
Showing Scour Pipe.

Appropriately named, these plates have collected fish regularly, the worst occasion in recent memory being back in 1959. Records did not exist for the numbers of fish lost to the plates prior to 1977 when the present superintendent thought it relevant to keep an unofficial record. This was no doubt, initiated due to the drought of 1976 and the records have been regularly entered up since, and form the basis for this study.

Stocks Reservoir has been fished by Stocks Angling Club since the 1960's, the unproductive nature of the water only providing a marginal fishery. Since the 1970's diagnostic fishing has been carried out by the club members with the intention of monitoring the quality and type of fishing that the reservoir can produce. The more recent intention has been to make the reservoir available to the public to fish on a day ticket basis and plans to utilise the whole catchment have been in hand since the late 70's. In September of 1983 the Water Management Committee approved a plan for a public fishery on Stocks Reservoir and this was subsequently passed by the board in January 1984.

The proposal was to put the fishery out to tender with a closing date in April, 1984 for the start of fishing in March of 1985. The Authority proposed to provide necessary basic facilities for access and fishing such as car parks, tracks, sewerage, cabin accommodation and electricity.
This degree of development and provision of facilities required a lease of 7 years and an option available for two further 7 year periods. In addition to providing this infrastructure the Authority proposed to help initially stock the reservoir with a reasonable head of fish to provide a good "put and take" fishery. A heavy stocking of 100 lbs. per acre was stated with the reservoir at a standing summer level of 210 acres. Therefore, 21,000 lbs. of fish is to be introduced, half of which will be provided by the Authority on a long lease basis, the tenant replacing this stock on termination of the lease. The lease also stipulated that at least 30 day tickets will be available to the public and that the tenant will also provide boats for fishing.

With a development of this nature the intention to make it succeed is clearly stated in the ample stocking density of 100 lbs./acre. Although this density decreases to about 60lbs/acre when the reservoir is full there is a possibility that there could be substantial fish losses onto the fish plates at such densities. Excessive fish loss would not only mean a loss to the fishery but also an operational problem for the water treatment works in maintaining supply.

The objective of this study is to assess the degree and likelihood of fish ingress onto the fish plates at the present and proposed stocking densities. Also to evaluate the operational implications, and if necessary suggest methods of alleviating the problem. Three spheres of study have been undertaken to achieve these objectives, these being:-

1. To selectively stock the reservoir and monitor the angling club catches in order to assess the total population, relating it to fish plate losses and proposed stocking densities.

2. To monitor the fish taken from the fish plates and assess the reasons for their ingress.

3. To study the draw off tower and fish plates, and suggest ways of ameliorating or halting the loss of fish and consequent operational problems.

INVESTIGATIVE PROCEDURES

Fish Stocking

Stocks Reservoir, being a water supply impoundment is prone to severe seasonal fluctuations in water level, (see graph 1 and appendix 1). At top water level of 30.328 metres and 343 acres the density of fish will be at its normal winter biomass and as the area decreases in the dryer summer weather the density of fish will increase. An area of 210 acres was calculated to be a good average summer level for the reservoir. At 5 metres draw down this area existed for half of the time between April and October. Consequently it was decided to stock fish, under the tenancy agreement, at this average water level with 100 lbs./acre. Subsequently as the reservoir level increased or decreased so would the density of fish, approximately in inverse proportion to the area.

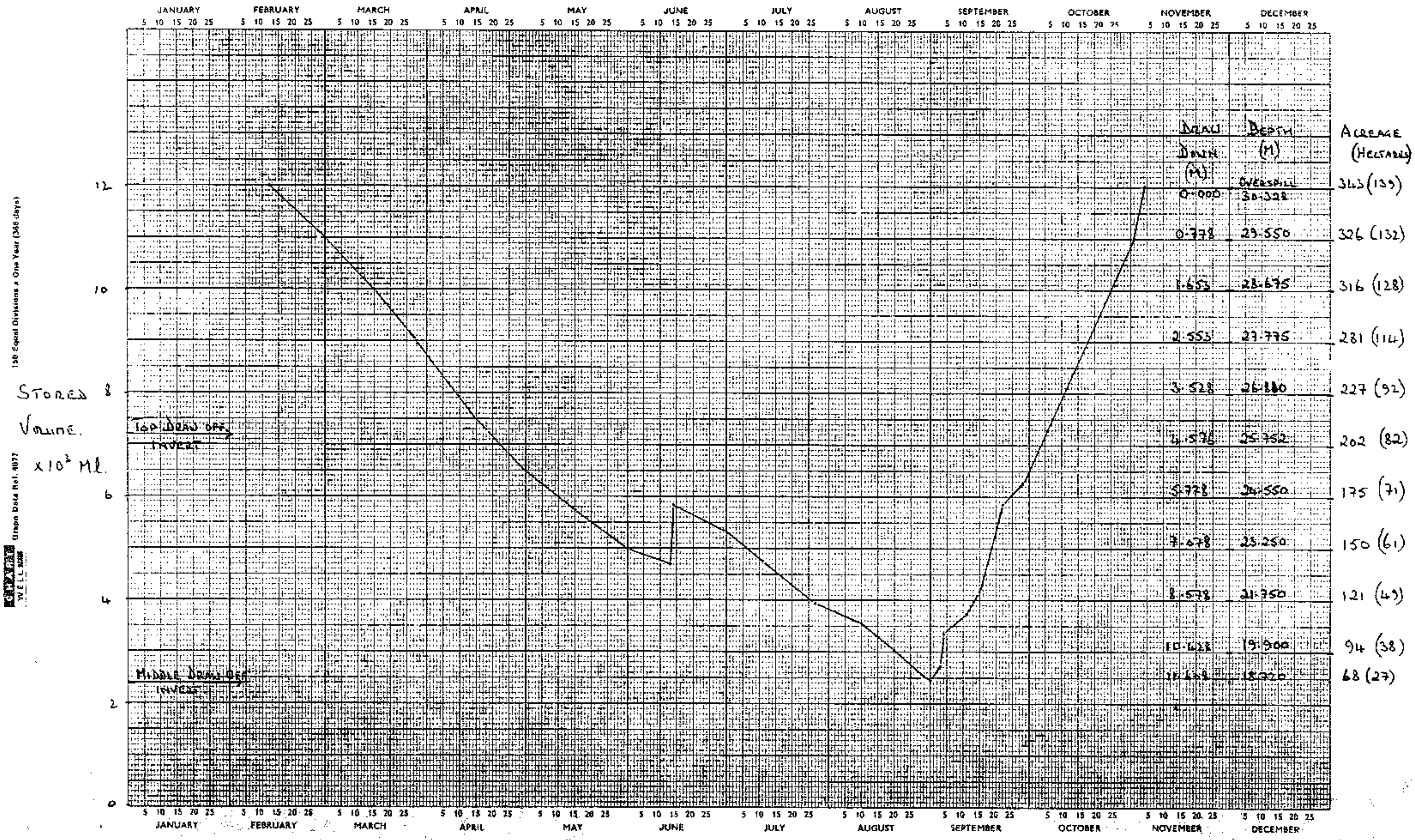
In order to simulate the anticipated heavy density of fish stocking it was proposed to stock the reservoir in 1984, for this study, twice. The initial stocking took place in March, when the reservoir was 2.5 metres down and covered 280 acres. The stocking of 1,000 rainbow trout took place in the neck of the reservoir near the dam, see map 1, thereby concentrating the fish to a partially confined area of the reservoir, near the draw off tower for the first few days. The relatively early date for this stocking was to enable a complete season for the study of angler catch population analysis. The second stocking consisting of 2,000 10"-12" Rainbow Trout took place in July when the reservoir was considerably lower. These fish were stocked in the same location to try and simulate the heavy density of fish and the water level was down 8.5 metres and the reservoir covered about 130 acres.

All 3,000 fish stocked were marked for ease of recognition by adipose fin clipping. This was carried out at the fish farm prior to transportation and stocking, 24 hours before release. Any loss of fish due to marking trauma could be accounted for, of which where was none.

The marking of fish could enable the experiment to detect any of these alien fish that subsequently end up on the fish plates, the draw off tower being so close to the place of stocking. Additionally the marked fish could be recognised to see where and how quickly they spread throughout the reservoir. But ultimately the proportion of angler caught marked fish to unmarked fish would give the study an indication of what the fish population was in the reservoir. With this quantity, or biomass of

Stocks Reservoir 1984 Draw Down Curve

Graph 1.



1984

fish it was intended to compare the existing density and fish loss on the fish plates with the proposed stocking density and potential fish loss.

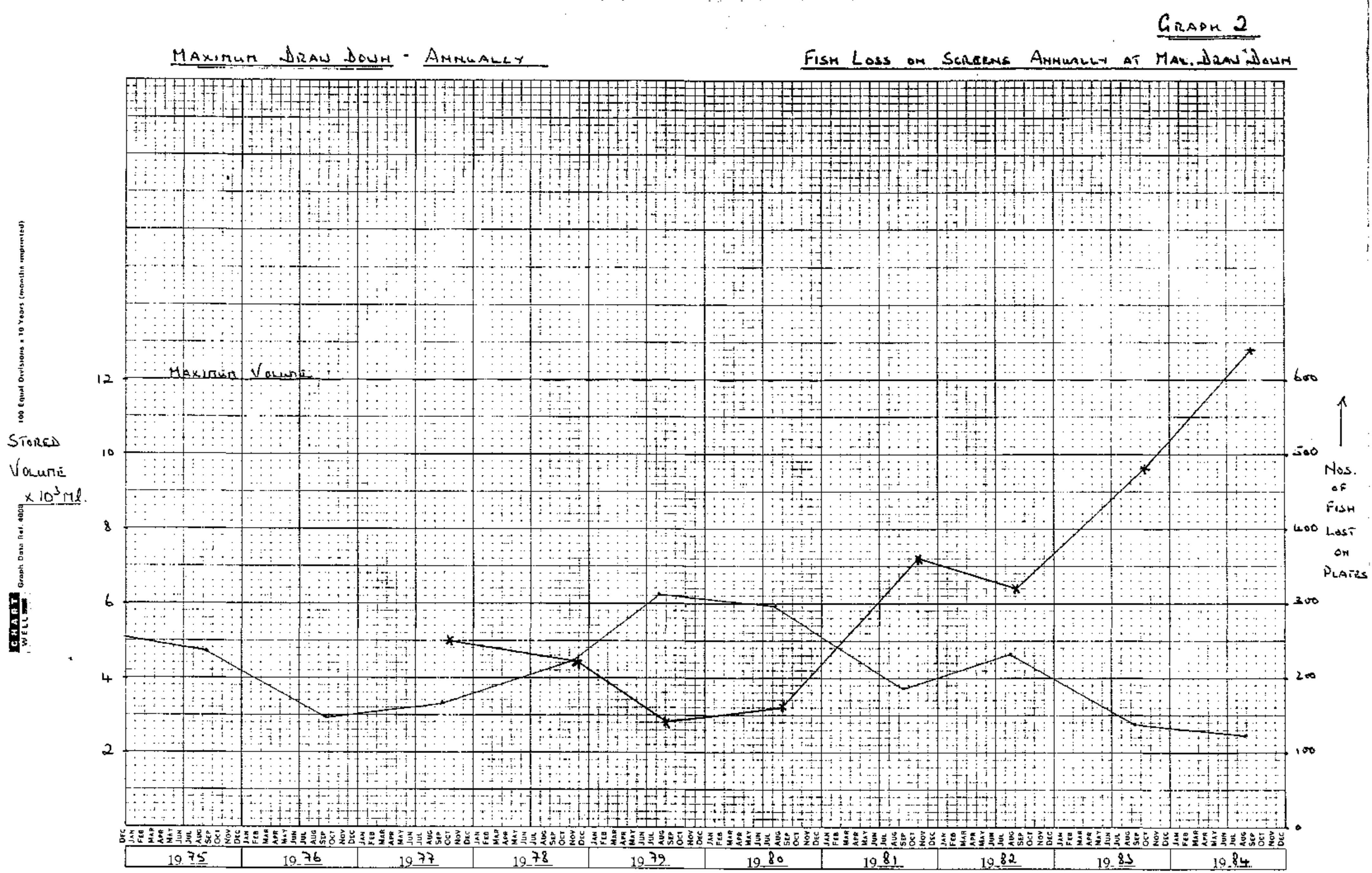
Anglers Returns

In order to obtain the recapture of the stocked marked fish Stocks Angling Club kindly agreed to help the sampling programme by reporting all fish caught this season. Each member was circulated, (appendix 2) explaining what an adipose fin clipped fish looked like in order to reduce the error in unrecognised sampling. Additionally they were all given pre-paid catch return forms (appendix 3) which required them to note the fish caught, on each and every day fished, whether it was marked or not, its size and weight plus the location caught. The last detail not only enabled a study on how the fish spread out after stocking but additionally on identifying the preferred areas for fish and assess if there was any additional threat to the treatment plant.

Treatment Plant Fish Plates

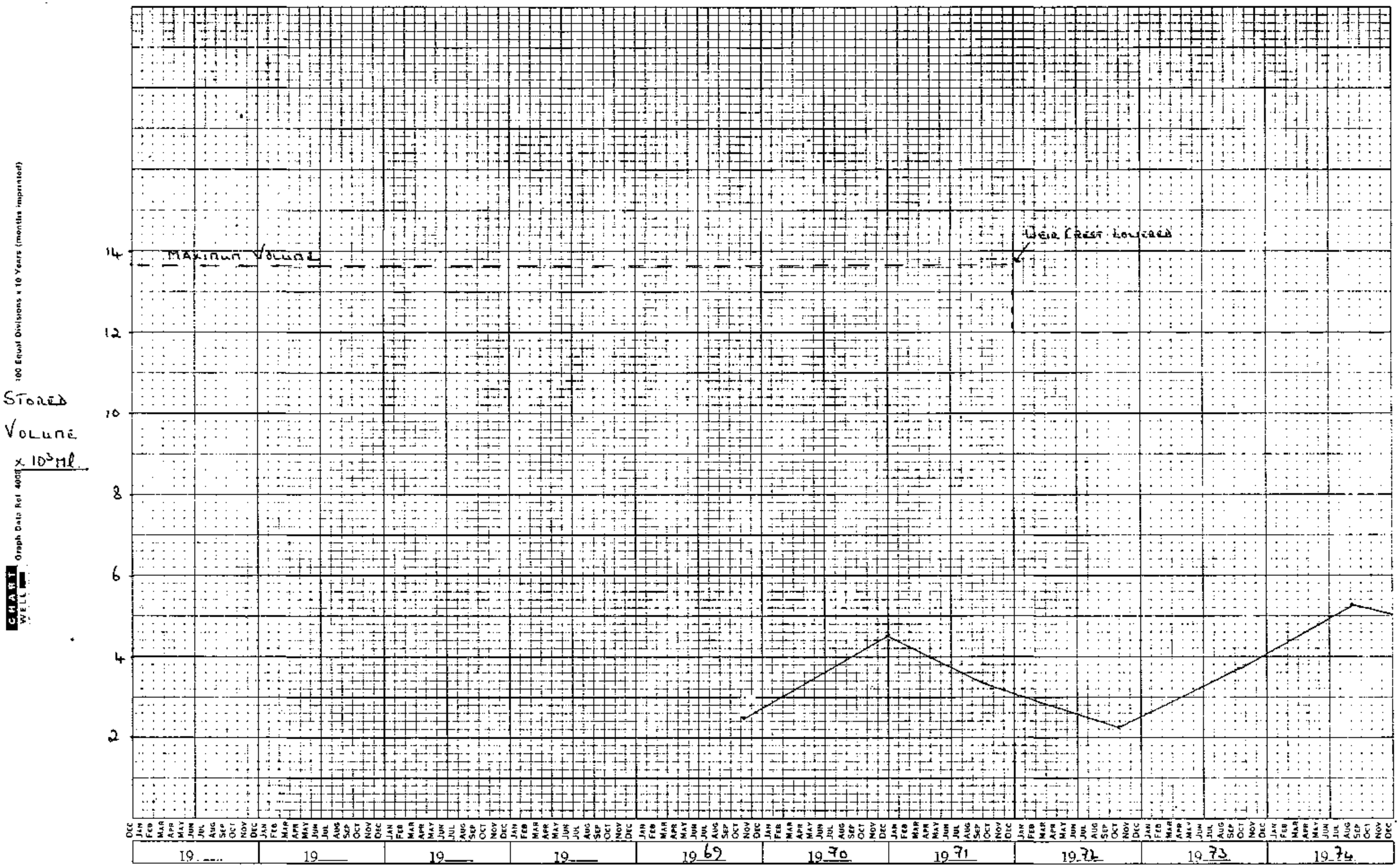
Water from the reservoir is drawn by gravity into the 24" draw off ports in the valve tower over which there is no screen or barrier. Any one of the three draw off levels can be utilised, excepting when it is within six feet of the surface, or of course out of the water. Air entrainment, with vortices developing, reduces the flow down the main, consequently when the reservoir level drops a combination of port openings is used to maintain supply. The usual practice is to use the port nearest the surface but if the water level drops within the six foot criteria then the lower port is opened 6" to 9" at a time. Ultimately, in times of drought the lowest of the 3 ports is fully open with the top and middle out of the water, but this occurrence is about a 1 in 10 year event, (graph 1). Selective use of the draw off level is utilised in the event of poor water quality at a particular level but when the reservoir level is low this facility is obviously not available.

Water drawn off the valve tower into the vertical collecting pipe ultimately connects to a 33" main which runs under the dam to the treatment plant. This direct supply main branches off into two 27" mains, below the floor of the works (see diagram). One branch supplies water to 7 batteries of filter shells, the other to 11 batteries of filter shells. Another 4 batteries of filter shells are supplied separately from a 33"


GRAPH 2
MAXIMUM DRAW DOWN - ANNUALLY
FISH LOSS ON SCREENS ANNUALLY AT MAX. DRAW DOWN
MAXIMUM VOLUME
STORED VOLUME x 10³ Ml.
NOS. OF FISH LOST ON PLATES
12
10
8
6
4
2
600
500
400
300
200
100
0
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
100 Equal Divisions x 10 Years (months imprinted)
CHARTWELL Graph Data Ref. 4008

GRAPH 2A.

MAXIMUM DRAW DOWN - ANNUALLY



pipe from the incoming main. In total there are 22 vertical pipes supplying water to the batteries. For batteries 1-18 each vertical pipe branches into two, and into each branch a filter chamber is incorporated(approx. 12' above floor level) with appropriate valves, allowing the removal and cleaning of one chamber without disrupting the flow to the battery. The supply pipes to batteries 19-22 are unbranched and each one contains a single filter chamber situated below ground level under the steel floor plates. The total number of filter plates in the water treatment is therefore 40 [(18 x 2) + 4].

Access to each metal filter plate within the chambers is via a relatively small 8" opening over which a steel plate is bolted onto studs by eight hexagonal nuts. Each filter plate can be slid out of the filter chamber for cleaning and removal of debris and fish. Operational cleaning of the plates is carried out routinely at least once a week, but also whenever a significant pressure drop is indicated between the inlet and outlet to any filter chamber.

It is this routine cleaning that has provided the annual totals of fish entrained onto the plates, records for which exist since 1977. The purpose of this years study was to assess the number of fish lost to the plates so as to be able to relate these losses to the exact numbers of known stock fish and estimated wild fish. Accurate records had to be kept by the treatment plant operatives as to the species of the fish, brown or rainbow trout, as well as their approximate size. All fish taken from the plates were kept in a freezer so that fisheries staff could confirm the species and size and condition of the fish. Some fishes stomach contents were analysed to assess the diet of those fish sucked into whichever draw off port. This was intended to assist in determining the pattern of behaviour common to those fish that were lost to the plant.

The fish plates that were occluded by fish produced the tell tale loss in pressure across the battery of filter shells. At times of severe ingress of fish nearly all batteries are affected but at other times and during the isolated pressure drop incident any battery may be affected. Records of the cleared batteries were kept to assess any possible pattern or preference of occlusion.

Other factors that may affect the ingress of fish could be the velocity of the inflow through the draw off valves and so records have been extracted of the flows through the plant at times of ingress. Additionally this needed to be related to the density of the fish in the reservoir, especially in close proximity to the draw off tower. Consequently the reservoir capacity was analysed in relation to total fish ingress into the plant and all other environmental factors that would produce an ingress of fish were examined, such as rainfall and consequent turbidity and hazen figures.

A further 2 sources of fish loss from the reservoir, other than by the draw-off to supply exist. They are either by way of the overspill or via the compensation/scour. The scour draw off from the resrvoir is the same pipe as that of the compensation and positioned 10 metres lower than the bottom draw off pipe in the tower and 20 metres further out into the reservoir. (See tower plan).

Compensation water flows from the reservoir into the River Hodder continuously, via the treatment plants electricity generation turbine. The statutory compensation is 4 m.g.d. during the summer months of April-October and 3 m.g.d. for the remaining winter months. There are no fish plates or screens for this discharge, however, it is possible to monitor the outfall by either netting the outlet mushroom or surveying the ponded up area of water before it flows over weir boards into the river. Scour water passes out of the plant through the same outlet as the compensation flow, the waterbank. The waterbank is a compensation flow that has been designed to assist the passage of migratory fish up the Hodder in times of low flows when fish are congregated in the lower reaches of the river during autumn. Extensive analysis has shown that salmon will migrate up the Hodder when at least 100 m.g.d. is flowing. Thus, the waterbank reserve of 200 m.g.d. enables 4 releases of 50 m.g.d. to be released on the tail end of an existing spate to simulate a spate of at least the 100 m.g.d. criteria. Therefore, flows into the scour will be normally 50 m.g.d. down the 36" compensation pipe. The scour as such is very rarely used because the waterbank compensation serves the same purpose. However, discharges of 130 m.g.d. at maximum could be released.

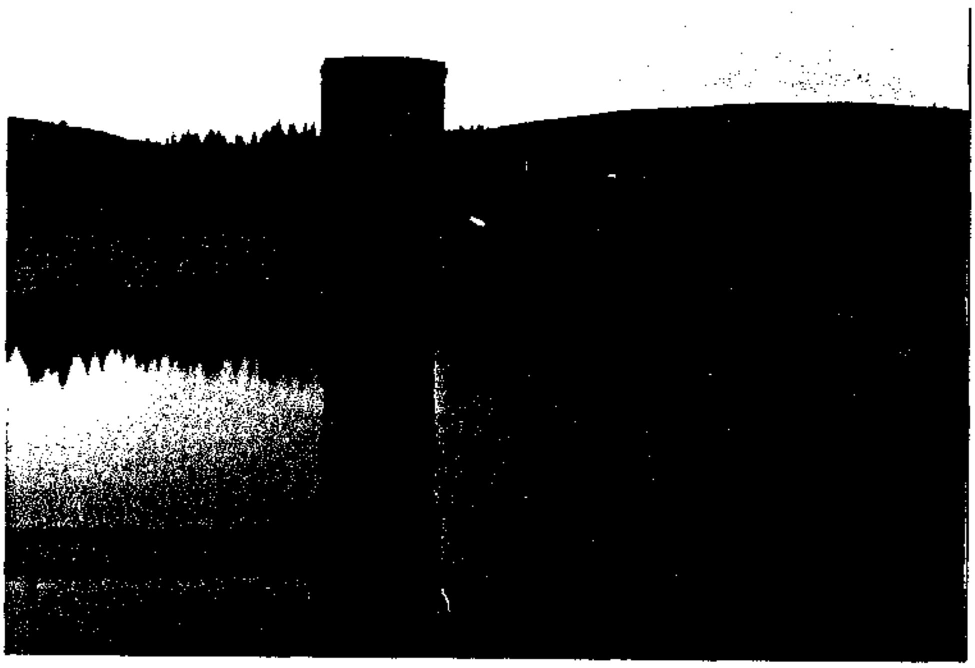
Plant Operational Alternatives

In order to be able to make recommendations on ways of stopping, or at least ameliorating the ingress of fish into the treatment plant it was necessary to look at operational structures and methods. If it proved necessary to prevent fish entering "the pipe" the first line of defence is the valve tower inlets, the 3, 24" ports. The second line of defence is the present first line, the fish plates.

The fish plates on 18 of the 22 batteries were designed in parallel pairs for each battery which allowed for the maintainance of supply whilst the plates were being cleared. However, the 4 most recent batteries 19 to 22 only have one single in line plate which requires the battery to be switched off during the complete clearing period. The inconvenience of this needed assessing along with the time taken to clear a fish plate and the subsequent total operational cost.

Routine maintenance stipulates that the 22 fish plates are checked once a week, normally on the night shifts. This entails little inconvenience but when the ingress of fish is severe enough to require continual clearing of the plates, for a number of days, operational problems could arise. Loss of pressure to supply is the only damage that can arise from this "fish overload" situation and only by permanent fish plate manning can the situation be eased and supply pressure regained. In addition to routine time commitment analysis, the overload manning time had to be studied not only from a total cost angle but also for a cost benefit analysis. The total cost was studied in relation to reducing the manning time to clear the filters by making the operation much faster. The cost benefit analysis was studied in relation to any extensive works done to the valve tower to effectively make the fish plates redundant and do away with the need to clear them at all.

Valve Tower Specifications



The valve tower as seen in the photograph and in diagram **1**, is a hexagonal structure of concrete and stone sets. It stands about 100 feet off the toe of the dam embankment and is 17 feet across from wall to wall. The draw off ports consist of a 24" pipe bellmouthed to 29" where it is set into the facia stone. The 24" pipe reduces through 2, 21" valves, 6 feet and 8 feet inside the draw off aperture and 3 feet before the draw off connects with the 24" vertical collecting main. The vertical pipe receives the three draw off inlets from three different angles each one set 45° off the other. These angles correspond to each upstream facia wall of the hexagonal tower. The lowest draw off level, no. 1 faces directly upstream into the reservoir and sits 1 foot off the stone pitched dam wall. Draw off no. 2 faces to the left (N by W) of the reservoir with its invert level exactly 30 feet above no. 1. No. 3, the top draw off port faces to the right (E by N) of the reservoir (seen in photograph) with its invert level exactly 24 feet above no. 2, the middle one and 14.5 feet from the revised top water level. This top water level was lowered by 4 feet when the overspill was lowered for safety reasons in 1972.

The exclusion of fish from the treatment plant requires there to be a barrier in front of the draw off ports on the valve tower. For the purpose of this sphere of investigation it was considered necessary to study different types of barrier. The barrier would have to be either physical, chemical or electrical and either on one, two or all three draw off ports. The extent of screening is very much dependant on the operational needs of the plant, as to whether it is decided to have 100% screening or just to prevent the "fish overload", once a year situation. The latter could therefore only require the lowest and middle draw off ports screened. Consequently various options were studied.

The physical barriers considered were either fixed or floating. The fixed steel bar barrier with automatic raking is of classic design whereas the fixed net hung from a top water level collar, secured to the tower is potentially feasible but has practical problems, though used elsewhere. Such a net would hang about 80 feet but a floating net that covers the one or two ports nearest the surface would only need to be about 45 feet deep.

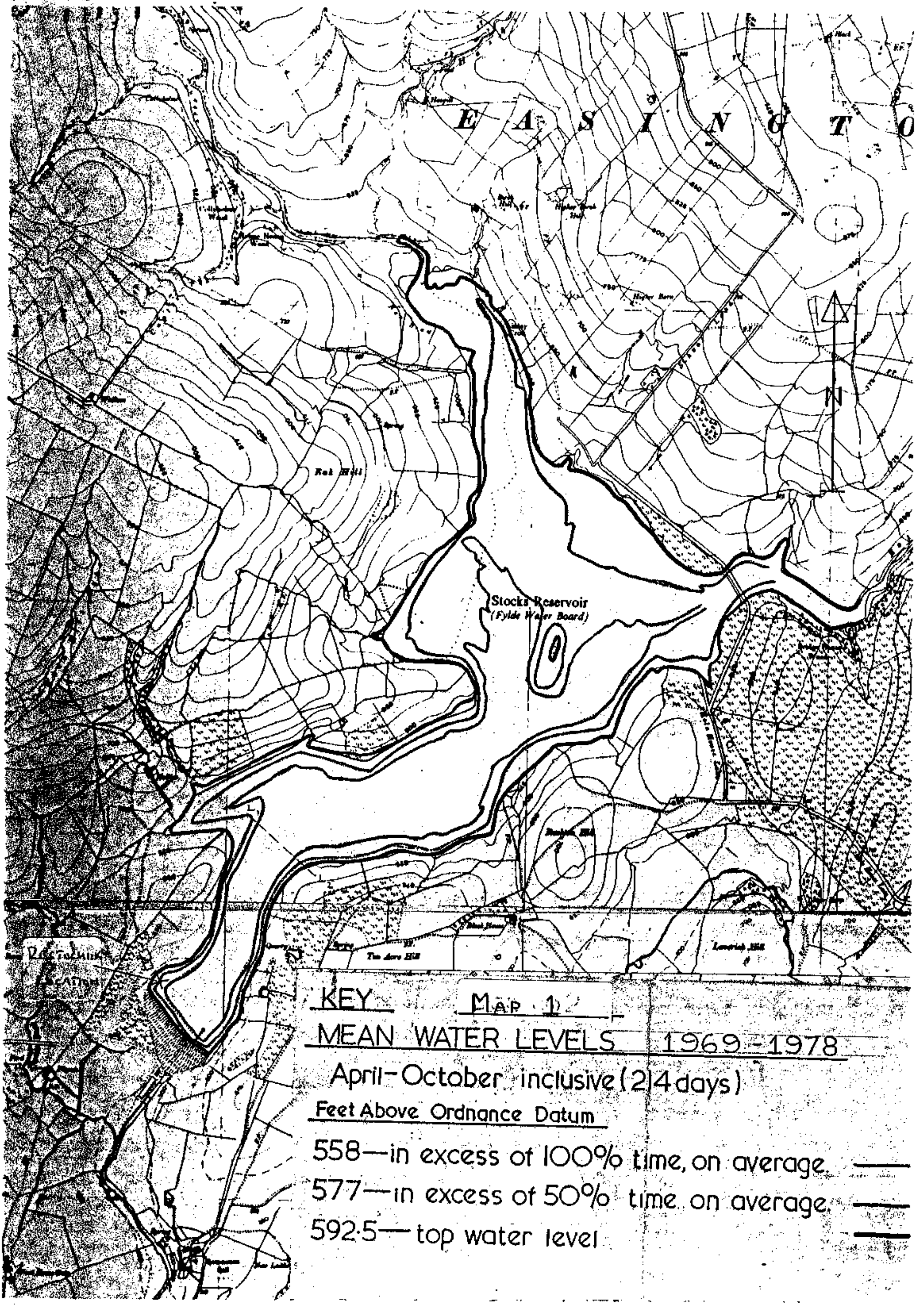
An electrical barrier is a method of screening used in similar situations, not only on lake sites but also river abstraction sites. Problems with health and safety as well as efficiency have been experienced. Finally a novel method of screening will be considered; a chemical barrier. Prechlorination of the drawn in water would have a repulsive effect on the fish that come into the vicinity of the pipe. In order to effectively study all of these screening methods the velocities of water and fish swimming speeds have been appropriately analysed.

Fish Stocking

On March 28th the 1,000 rainbow trout of 10"-12" were stocked in the reservoir below the board house, as marked on the mean water level map of Stocks Reservoir. This number of fish has an approximate weight of 700 lbs. and so by stocking into the reservoir when at 280 acres in area, produced an increase in overall fish density of about 2.5 lbs./acre. This insignificant change in density can be compared with the alteration of density in the vicinity of the dam (south of L_1, $-L_2$ on map) and draw off tower. This area would be about 25 acres at 2.5 m. draw off on the reservoir which would produce a fish density increase of 28 lbs./acre. This does not compare with the proposed densities but however, there must have been a short period of high density immediately after stocking. It is of interest to note from anglers returns that 6 days later on April 4th stock rainbow trout were being caught in good numbers at the head of the reservoir, showing how well and quickly the fish dispersed.

The losses on the fish plates (see table 1.) did not record any stock fish being drawn in at the time of stocking but there was an increase of small brown trout. This occurred four days after stocking at the routine fish plate clearance time, with a further influx of brown trout later in the week. It is significant that no stocked rainbow trout ended up on the plates but the increase in brown trout is probably due to the disturbance and displacement by the rainbow trout forcing the brown trout to forage in the proximity of the draw off tower.

The second stocking took place on July 24th with 2,000, 10"-12" rainbow trout introduced to the reservoir in the same place as before. The weight of these fish was approximately 1,400 lbs. and so with the reservoir at 130 acres the increased density would have been about 11 lbs./acre. Yet in the vicinity of the dam, the area to the south of L_1, $-L_2$, the reservoir was about 20 acres which would give a fish density at the time of stocking of about 70 lbs./acre. This temporary heavy density is in keeping with proposed practices and yet it is noticeable that no significant increase of fish into the plant occurred after the stocking. This applied to brown trout as well as rainbow trout although on this occasion there were two rainbows drawn into the plant. Anglers catch returns confirmed previous findings that the stock fish spread throughout the reservoir quickly with clipped rainbow trout caught on the next day in the vicinity of the island. At this reservoir level the island is nearly the head of the reservoir. The fish caught so soon after stocking were possibly from the March stock but it is noticeable that the returns of stock fish soon rise after the July stocking, indicating the affect of the introduced fish.


E A S I N G T O
N
Stocks Reservoir
(Fylde Water Board)
KEY
MAP 1
MEAN WATER LEVELS 1969-1978
April-October inclusive (214 days)
Feet Above Ordnance Datum
558—in excess of 100% time, on average
577—in excess of 50% time on average
592·5—top water level

RECORD OF FISH TAKEN FROM FISH PLATES - 1984

Table 1.

DATE	FISH TAKEN Per Clearance	Running Total	Brown S	Brown M	Brown L	Rainbow S	Rainbow M	Rainbow L
Jan 3rd	2	2	2					
Jan 10th	2	4	2					
Jan 13th	2	6	2					
Jan 14th	1	7	1					
Jan 17th	1	8		1				
Jan 24th	1	9		1				
Jan 31st	2	11			1	1		
Feb 12th	1	12		1				
Feb 20th	3	15	1	2				
Feb 27th	2	17					2	
Mar 3rd	1	18		1				
Mar 20th	2	20	2					
Mar 25th	1	21				1		
Apr 1st	7	28	6	1				
Apr 2nd	3	31	2	1				
Apr 6th	2	33	1	1				
Apr 7th	5	38	4	1				
Apr 8th	4	42	4					
Apr 12th	2	44	2					
Apr 16th	3	47	3					
Apr 20th	2	49	2					
Apr 21st	3	52	3					
Apr 30th	5	57	4	1				
May 4th	6	63	3	3				
May 5th	2	65	1		1			
May 6th	1	66			1			
May 11th	3	69	2		1			
May 12th	1	70		1				
May 14th	2	72		2				
May 16th	1	73		1				
May 17th	1	74	1					
May 20th	5	79	1	4				
May 23rd	3	82	2	1				
May 25th	1	83		1				
May 26th	1	84		1				
May 27th	1	85		1				
May 30th	3	88		2	1			
June 2nd	2	90	1		1			
June 3rd	1	91	1					
June 4th	1	92		1				
June 10th	3	95	2	1				
June 15th	1	96	1					
June 16th	6	102	5	1				
June 17th	2	104	1	1				
June 18th	1	105	1					
June 21st	3	108	3					
June 28th	3	111	3					
June 29th	4	115	4					
July 11th	1	116	1					
July 13th	1	117					1	
July 14th	2	119	2					
July 15th	2	121	1	1				

DATE	FISH TAKEN Per Clearance	Running Total	Brown S	Brown M	Brown L	Rainbow S	Rainbow M	Rainbow L
July 27th	2	123		1			1	
July 29th	2	125		1			1	
July 30th	2	127		2				
Aug 2nd	1	128		1				
Aug 4th	5	133		3	1		1	
Aug 6th	2	135	2					
Aug 10th	1	136	1					
Aug 12th	8	144	7	1				
Aug 13th	1	145		1				
Aug 16th	1	146	1					
Aug 17th	1	147		1				
Aug 19th	4	151	3	1				
Aug 20th	3	154	1	1			1	
Aug 21st	4	158		2	2			
Aug 22nd	5	163		5				
Aug 23rd	4	167		3			1	
Aug 23rd	4	171	1	3				
Aug 23rd	4	175		4				
Aug 24th	10	185	2	8				
Aug 25th	16	201	2	11			2	1
Aug 25th	4	205		2	2			
Aug 26th	11	216	3	6			1	1
Aug 28th	4	220	3	1				
Aug 28th	1	221			1			
Aug 29th	20	241	8	12				
Aug 29th	13	254	3	7	3			
Aug 29th	9	263		9				
Aug 29th	15	278	10	5				
Aug 30th	37	315	25	10	2*			
Aug 30th	31	346	28	3				
Aug 30th	31	377	21	10				
Aug 31st	28	405	18	9	1*			
Aug 31st	6	411		6				
Sept 1st	17	428		17				
Sept 1st	9	437	5	4				
Sept 1st	4	441	2	2				
Sept 2nd	6	447		6				
Sept 2nd	9	456	5	3	1			
Sept 2nd	6	462	5	1				
Sept 2nd	5	467	3	2				
Sept 3rd	5	472	2	3				
Sept 3rd	5	477	4		1			
Sept 4th	100+	577	75	20	5*			
Sept 4th	6	583	5	1				
Sept 4th	11	594	8	2			1	
Sept 5th	15	609	6	9				
Sept 11th	26	635	20	6				
Sept 12th	1	636					1	
Sept 15th	2	638		1			1	
Sept 21st	4	642	3		1			
Sept 22nd	2	644	1		1			
Sept 28th	5	649		5				
		649	360	244	27	2	14	2

Postscript:-

October	9		9					
November	9							

SIZE OF FISH

L = Large > 12"
M = Medium 12" - 8"
S = Small < 8"

* Guestimate; 1 @ 3lb. 7oz.

Anglers Returns

All anglers returns were filed and recorded upon receipt and the results tabulated. The returns identified the species of trout caught as well as whether the rainbow trout were fin clipped or not. Also recorded from the returns were the numbers of undersize fish returned, their species and if clipped or not. Note that some stocked fish were returned if better fish had been taken by the angler or the fish was a bit small.

The returns indicated that 11.87% of the stock fish were caught this season, with only 356 of the 3,000 fin clipped fish being landed. This figure does include an allowance for an error, in that not all of the rainbow trout taken were recorded as fin clipped. Of the 82 fish not recorded it is estimated that 42 of these could have been clipped fish. Additionally half of the undersized, returned rainbow trout were considered to be fin clipped fish.

A total of 295 brown trout were landed and assuming that brown trout are as easily caught as rainbow trout a proportional estimation can be made to calculate the standing biomass of brown trout. This estimate was 2,174 lbs. of fish and along with an estimated population of undersize brown trout of 363 lbs. and a wild rainbow trout population of 413 lbs. the total biomass of "wild" fish in Stocks Reservoir at the start of the season was calculated to be 2,950 lbs. In addition to this weight was that of the stock rainbow trout which by the end of the season had an estimated total weight of 2,644 lbs. Consequently the total biomass of fish estimated to be in the reservoir after July 24th, the date of the 2nd stocking is calculated to be 5,594 lbs.

This biomass of fish produced a density of 26.64 lbs./acre when the reservoir was at 210 acres, but at low summer levels of 100 acres this density increased to 56 lbs./acre. At the lowest time during this study the area of the reservoir was about 62 acres, consequently the estimated density of fish would have been 90.22 lbs./acre.

It has already been pointed out that the stock fish were recorded by anglers catch to have moved out from the restocking site relatively quickly. The position from which an angler caught fish was recorded on his "return" and this information has been analysed by dividing the reservoir into 9 beats or lengths of bank. This is shown on the map opposite and for convenience the island was included in beat number 7. Angling in future will not be allowed from the island and the purpose of this exercise is to analyse where

MAP 2. ANGLERS BEATS AND AREAS OF RESERVOIR

MEAN WATER LEVELS 1969 - 1978

April-October inclusive (214 days)

the fish are gathered, and the island is closest to beat 7. The beats were analysed separately, see table **2** but for the purpose of identifying where the fish are, opposing beats were combined. In other words for the dam end beats 1 and 9 were combined. Beat 7 with Bottoms beck was considered in isolation for convenience as beats 3 and 6 were paired due to them sharing vast areas of shallow water that dried out when the drought progressed. Beats 2 and 8 were paired as the middle area of the reservoir and yet it could be considered that fish are more likely to move from beat 2 to 1 than 2 to 8. However, the holding and feeding areas are fairly well defined, as explained, and the numbers of fish caught from each paired area was displayed on a histogram for each monthly period. To expunge any favoured location regularly visited the data is computed to fish caught per unit visit table 3. Per unit visit was selected rather than hours fished, which would give catch per unit effort, because it was considered necessary to display the data as it usually is and such an approach is quite reasonableas the visits over a season will average out to a unit time.

The histograms of anglers catch per month show that the two stockings with rainbow trout produced significant increases in catches in the following month. This was seen to drop off after the months passing but certain beats retained better rainbow trout catches than brown trout. Beats 1 and 9 consistently had higher takes of rainbows with all beats having an average 2 fish per visit, with a slight decrease in this average the further up the reservoir was fished. This did not wholly apply in August as beats 2 and 8 were greatly preferred at over 5 rainbows per visit with the others between 3 and 4 fish per visit, excepting beats 4 and 5 which were dried up. Beat 7 had an unexplainable success with rainbows in June possibly due to the fact that the island became available for fishing, however, July was extremely poor. What is noticeable is the very low level of rainbows a month after stocking. The catches in May and September were less for rainbows than for brown trout, possibly reflecting the fair state of native brown trout stocks.

Brown trout catches were consistently better the further up the reservoir the beat, with beats 4 and 5 fishing very well in the early season to June. Beats 1 and 9 were poor for brown trout and although all beats looked good for brown trout in March with 2 or 3 fish per visit very few fish were caught in total. Beats 2 and 8, and 7 were most favourable for brown trout except possibly in the early and late season for behavioural reasons, with beats 4 and 5 returning good numbers of fish from the head of the reservoir. Beats 3 and 6 were generally poor with better brown trout catches than rainbow trout, the browns averaging out at 2 per visit.

STOCKS ANGLING CLUB RETURNS 1984

TABLE 2.

Anglers Visits with Location Fished

Month \ Beat	1	2	3	4	5	6	7	8	9	Total
March March	–	2	1	1	5	–	–	1	1	11
April	6	10	1	2	10	4	5	4	3	45
May	9	3	1	1	1	1	9	2	–	27
June	1	3	3	2	1	4	6	5	1	26
July	2	3	4	–	1	1	6	8	–	25
August	11	11	1	–	–	1	14	6	2	56
September September	3	3	3	3	–	–	2	2	–	16
										206*

* Total greater than Anglers visits due to some anglers fishing 2 beats in one day. Anglers visits totalled 219 including nil returns which totalled 34. Therefore 21 anglers fished 2 beats on one visit.

Fish Caught on Each Beat

Month \ Species	Trout B	R	Trout B	R	Trout B	R	Trout B	R	Trout B	R	Trout B	R	Trout B	R	Trout B	R	Trout B	R
March	–	–	5	–	2	–	2	–	18	5	–	–	–	–	4	–	2	–
April	4	17	14	20	2	–	6	2	16	18	12	9	8	9	5	9	4	6
May	9	6	4	2	2	1	3	–	1	1	1	1	22	10	2	4	–	–
June	–	2	6	–	5	7	4	–	1	1	6	–	17	24	8	3	3	3
July	–	4	3	8	11	7	–	–	1	–	–	1	15	2	23	15	–	–
August	13	41	12	62	1	5	–	–	–	–	1	2	19	56	13	28	–	5
September	2	2	11	3	5	4	10	1	–	–	–	–	7	1	4	3	–	–
Total	28	72	55	95	28	24	25	3	37	25	20	13	88	102	59	82	9	14

Cont'd...

TABLE 3.

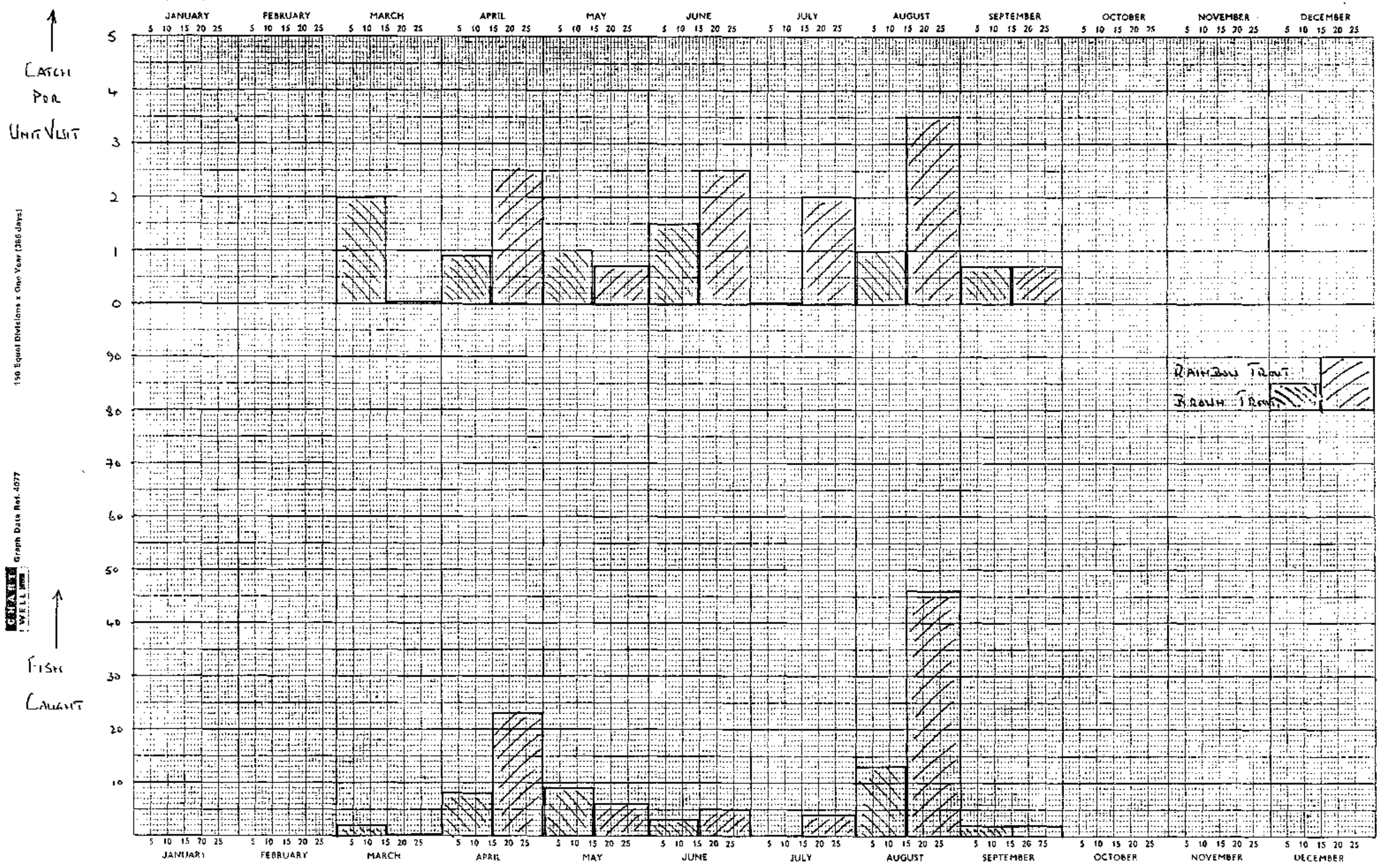
Fish caught and catch per unit visit for areas of the reservoir

Area / Species / Month	1 and 9		2 and 8		3 and 6		4 and 5		7	
	B.T.	R.T.	B.T.	R.T.	B.T.	R.T.	B.T.	R.T.	B.T.	R.T.
March	2	–	9	–	2	–	20	5	–	–
Catch/Visit	2	–	3	–	2	–	3.3	0.8	–	–
April	8	23	19	29	14	9	22	20	8	9
Catch/Visit	0.9	2.5	1.4	2.1	2.8	1.8	1.8	1.6	1.6	1.8
May	9	6	6	6	3	2	4	1	22	10
Catch/Visit	1	0.7	1.2	1.2	1.5	1	2	0.5	2.4	1.1
June	3	5	14	3	11	7	5	1	17	24
Catch/Visit	1.5	2.5	1.75	0.4	1.6	1	1.7	0.3	2.8	4
July	–	4	26	23	11	8	1	–	15	2
Catch/Visit	–	2	2.4	2.1	2.2	1.6	1	–	2.5	0.3
August	13	46	25	90	2	7	–	–	19	56
Catch/Visit	1	3.5	1.5	5.3	1	3.5	–	–	1.4	4
September	2	2	15	6	5	4	10	1	7	1
Catch/Visit	0.7	0.7	3	1.2	1.7	1.3	3.3	0.3	3.5	0.5

N.B. Catch/visit calculated on 206 beat visits. Actual visits were 219. Therefore a 7% error exists in catch/visit figures for absolute purposes.

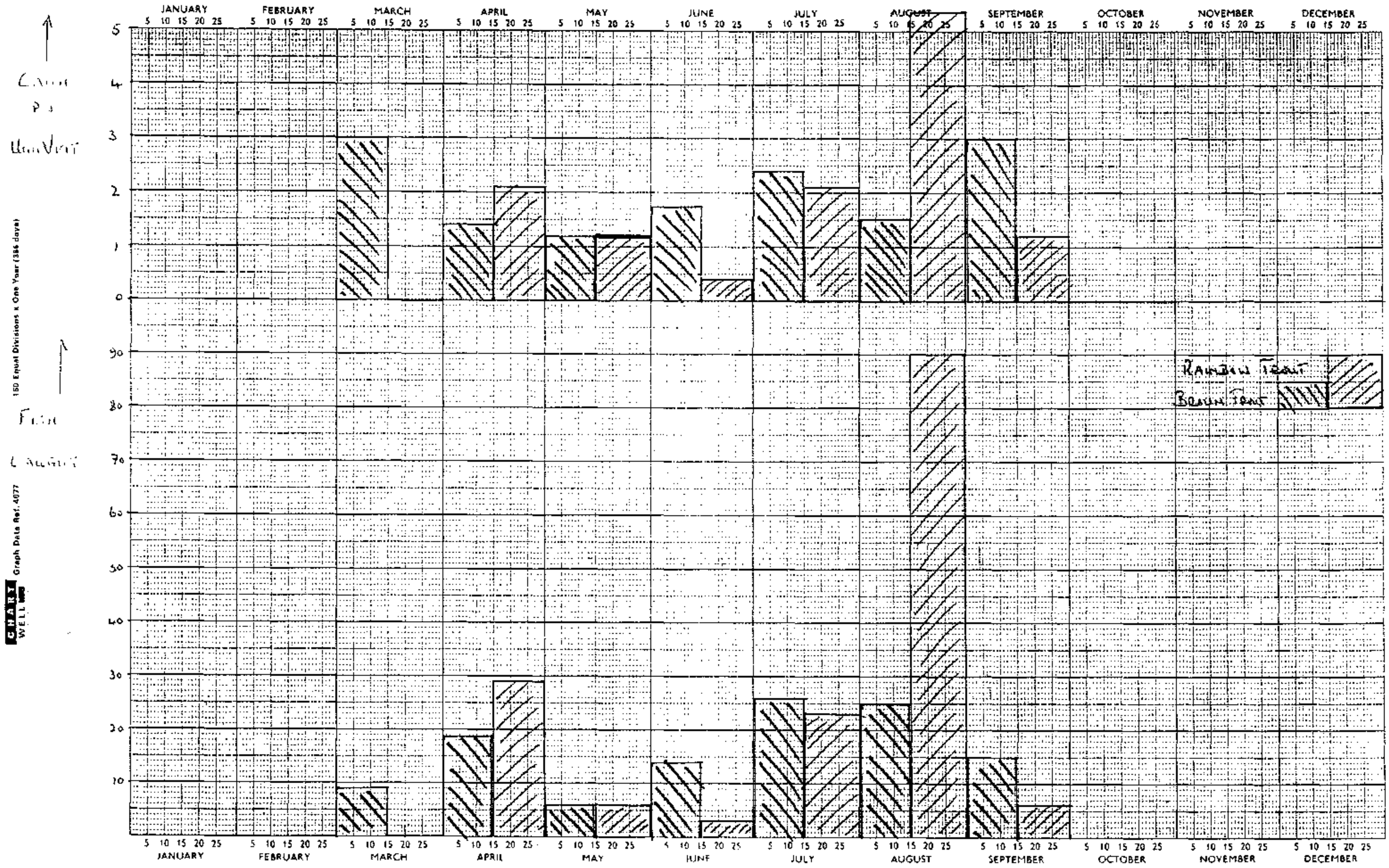
ANGLERS CATCH PER MONTH FOR BEATS 1 & 9

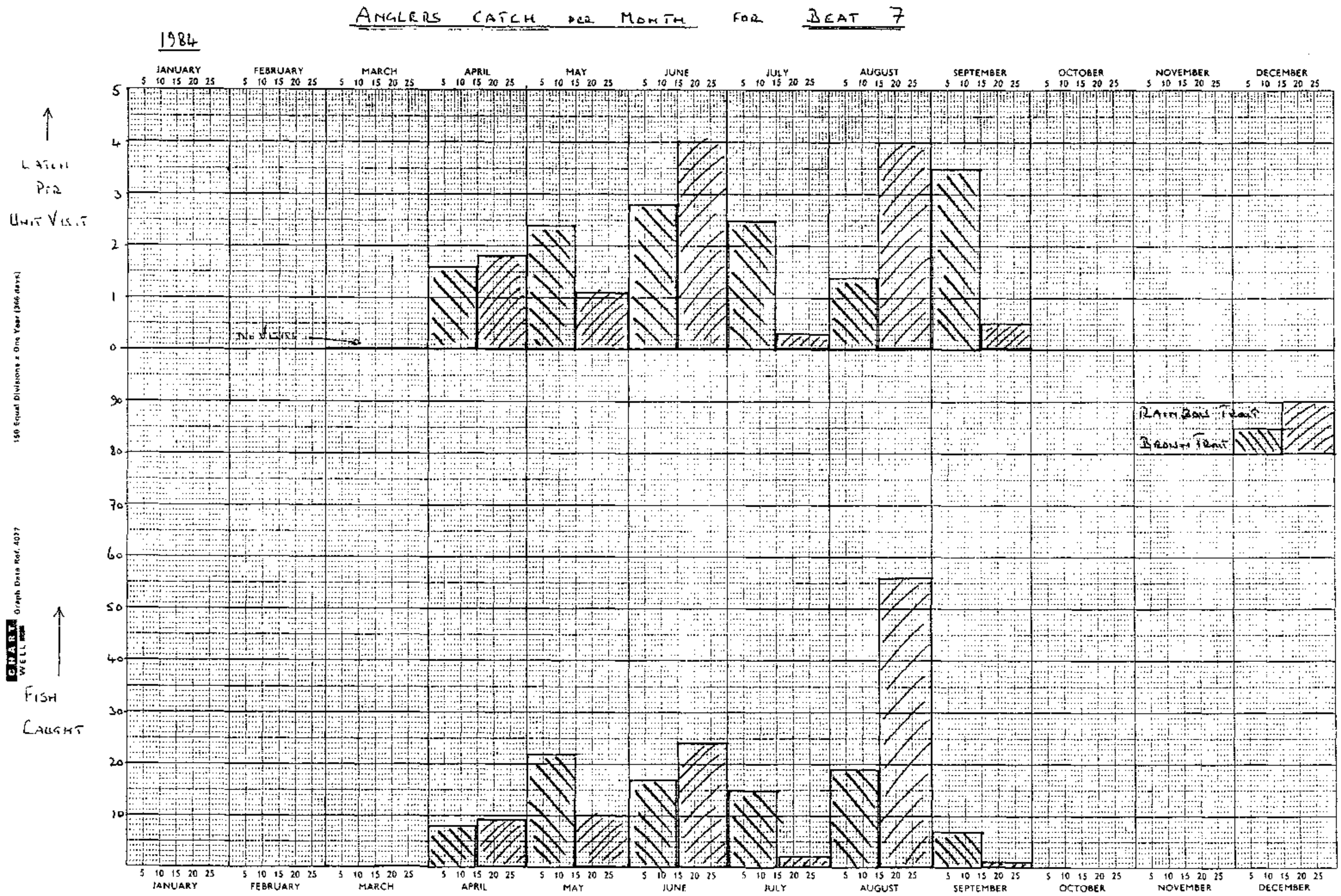
1984



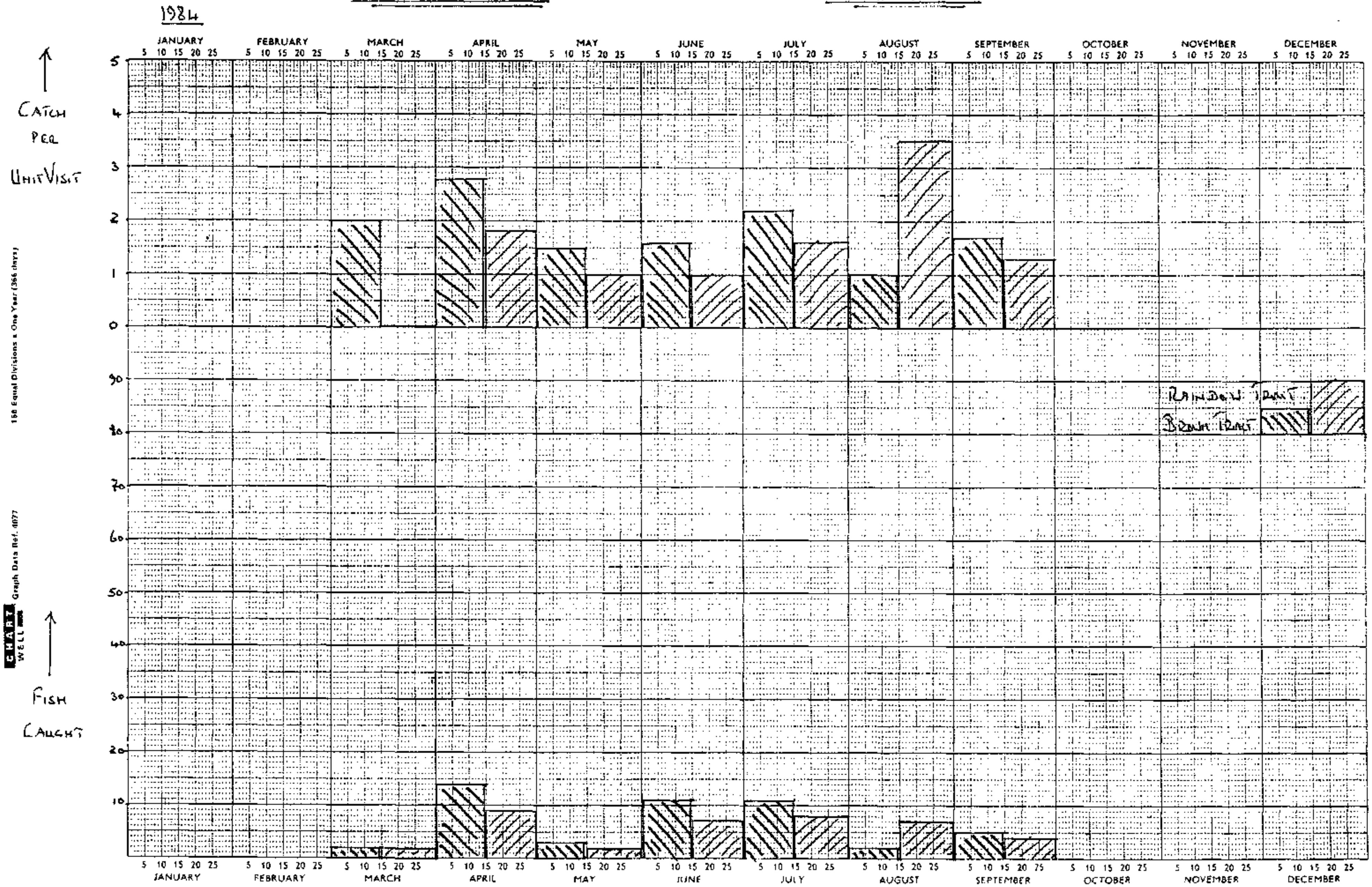
Anglers Catch per Month for Beats 2 + 8

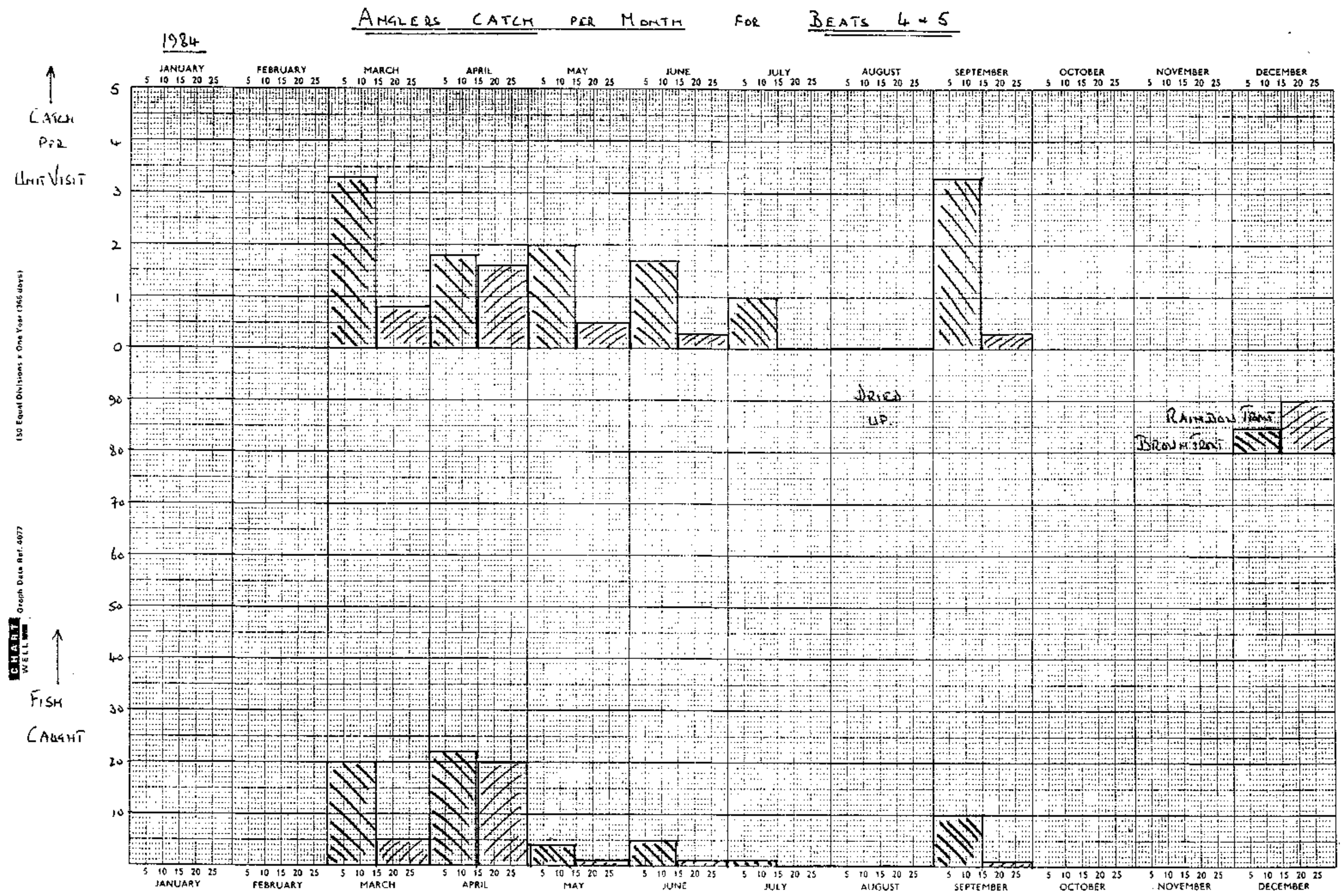
1984




ANGLERS CATCH PER MONTH FOR BEAT 7
1984
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
CATCH PER UNIT VISIT
FISH CAUGHT
No VISITS
RAINBOW TROUT
BROWN TROUT
150 Equal Divisions x One Year (366 days)
CHARTWELL Graph Data Ref. 4027

ANGLERS CATCH PER MONTH FOR BEATS 3 & 6





ANGLERS CATCH PER MONTH FOR BEATS 4 + 5
1984
CATCH PER UNIT VISIT
FISH CAUGHT
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
DRIED UP.
RAINBOW TROUT
BROWN TROUT
CHART WELL
Graph Data Ref. 4077
(50 Equal Divisions x One Year (366 days)

The July averages do not include the catches after fish were stocked on the 24th. These are grouped into August figures. It is worthy of note that the nett catch per unit visit is the sum of the brown and rainbow catches per unit visit which are generally quite good for this season. However, without the rainbow trout stocking they would be considered to be poor, averaging between 1 and 2 fish per visit.

Treatment Plant Fish Plates

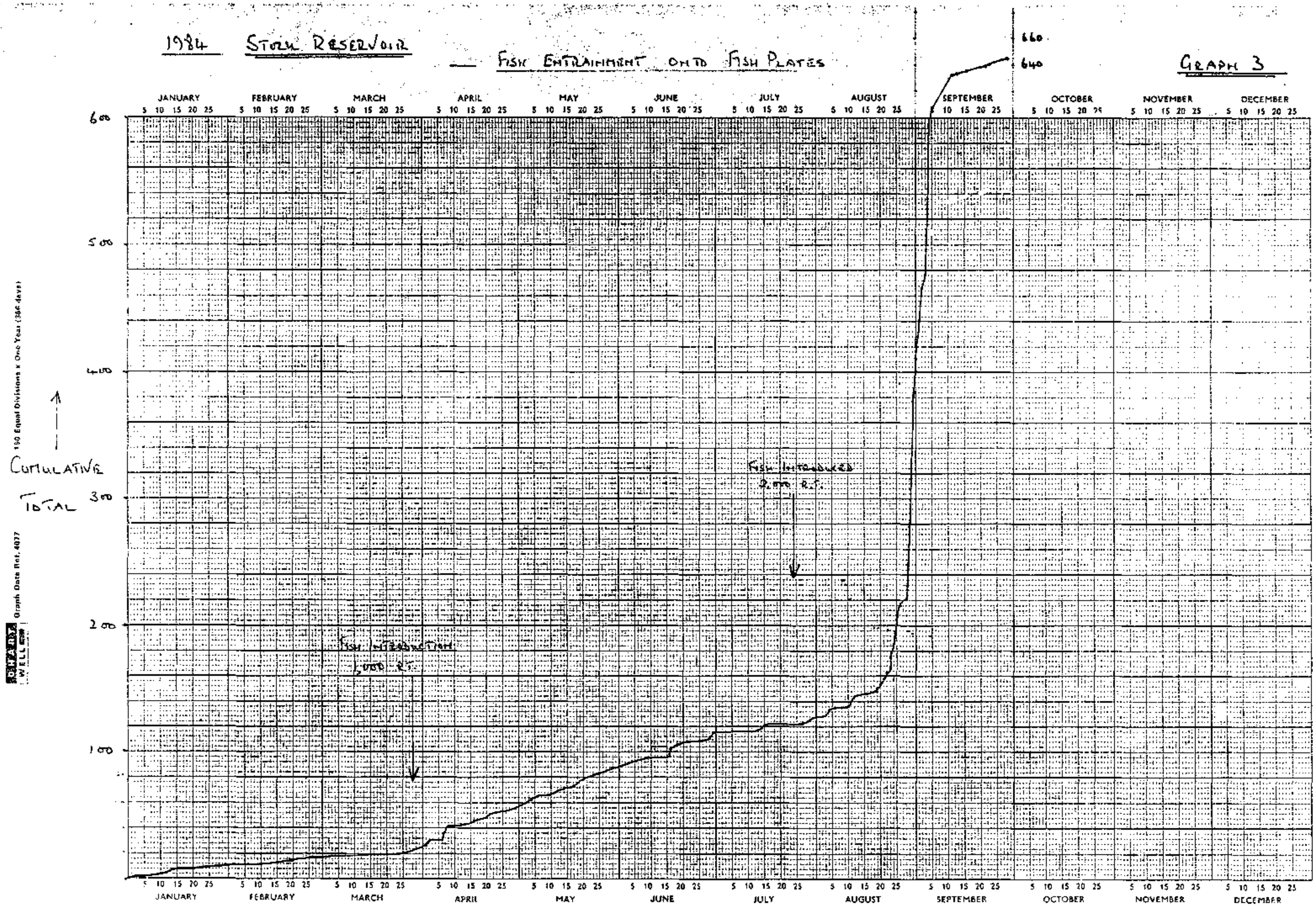
1984 was a record year for the number of fish drawn onto the fish plates, comparison being made on graphs 3 and 3A . Since records began in 1977 the totals had varied from about 160 to 540 but by the end of September this year the running total stood at 649. From the superimposed graph of previous years upon 1984's it is significant that the running total, to the middle of August, was well below average. At 150 fish on August 19th it was within 20 fish of the two lowest years on record, 1979 and 1980. These years ended up with totals of only 164 and 216 respectively, whereas this year there were over 500 fish in the month and a half to the end of September.

Table 1 displays the running totals of fish recorded by the operatives in the treatment plant. The significance of this data is in the species and size classification. There were only 18 rainbow trout taken out of the 649 total, which at 2.8 % of the total is a significantly small number. Of the 631 brown trout 57% were small fish of less than 8" which is a high proportion but to be expected if the high intake velocities of water preferentially draw in the smaller fish. The large fish of greater than 12 inches totalled 27 which is not great but it is of interest that most of these fish were taken throughout the year and not just on the dates when a lot of fish were drawn in. The medium sized fish that would make the bulk of the takeable brown trout to the angler was 38% of their total. This is about two thirds of the smaller fish taken and in comparison with the anglers catch population estimate it appears that the undersized brown trout biomass of 363 lbs. could be an underestimate.

The fish cleared from the filter plates come from specific batteries and the record of these is shown in table 4 . When large quantities of fish had to be cleared these records could not be kept due to time availability, however it was noted that all filter plates tended to block. Generally batteries 8 to 12 and 1 to 4 needed clearing most often. This is in keeping with operational impressions over years of clearing.

1984 Stour Reservoir — Fish Entrainment onto Fish Plates

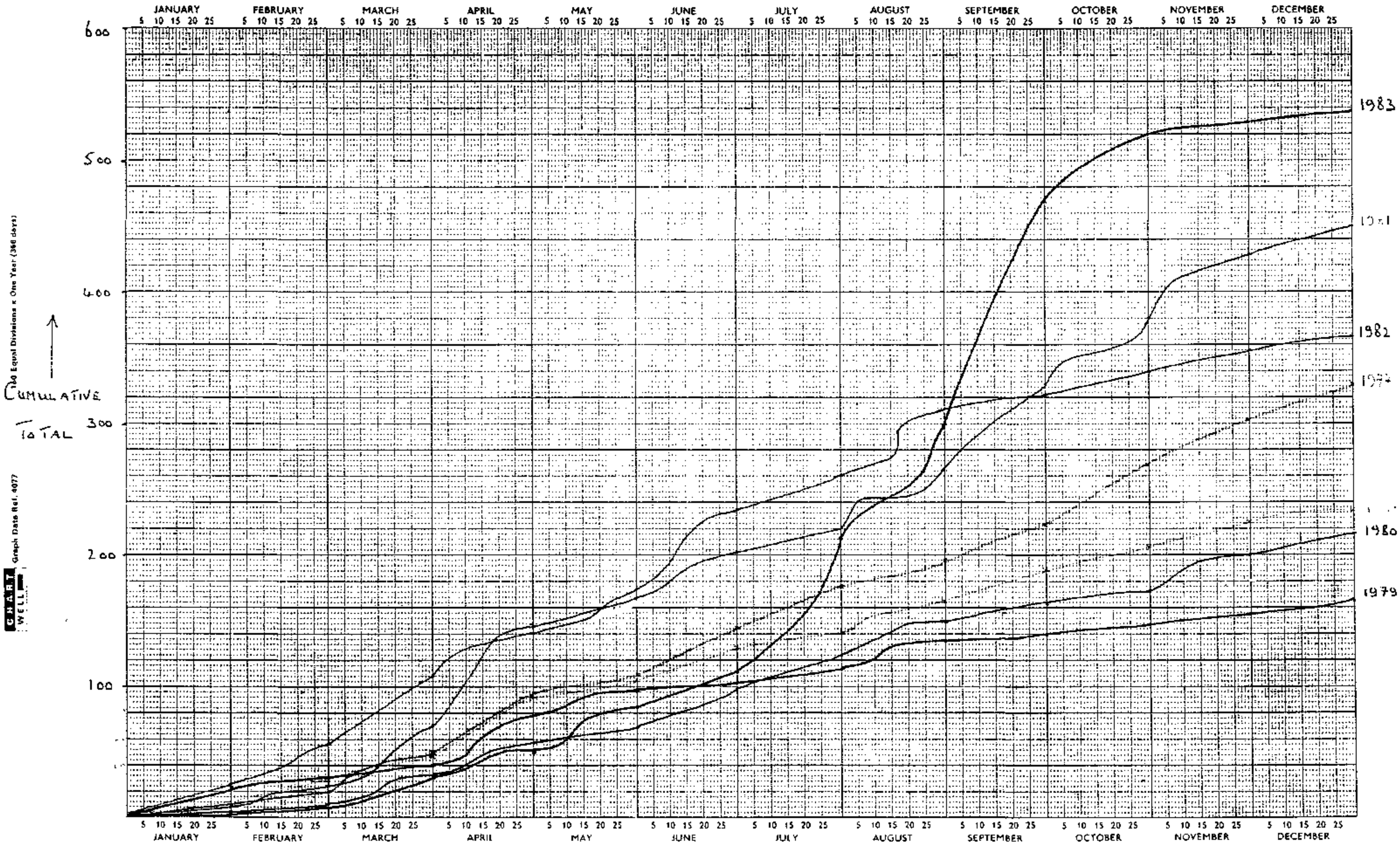
Graph 3



1984

1977 - 1983 STOCK RESERVOIR — FISH ENTRAINMENT ONTO FISH PLATES.

GRAPH 3A.



1984

Table 4.

STOCKS RESERVOIR FISH PLATES

Numbers of Fish for respective battery fish plates

from 28.4.84 to 6.8.84

Battery Number		Total Fish
1		7
2		5
3		4
4		4
5		1
6		-
7		1
8		7
9		3
10		7
11		4
12		8
13		-
14		2
15		3
16		6
17		3
18		3
19		3
20		-
21		4
22		3
	TOTAL	78

N.B. In the month following 6.8.84 the fish count rose from 148 to 622. These additional fish were cleared from all batteries with no apparent preferential blocking of any set of batteries.

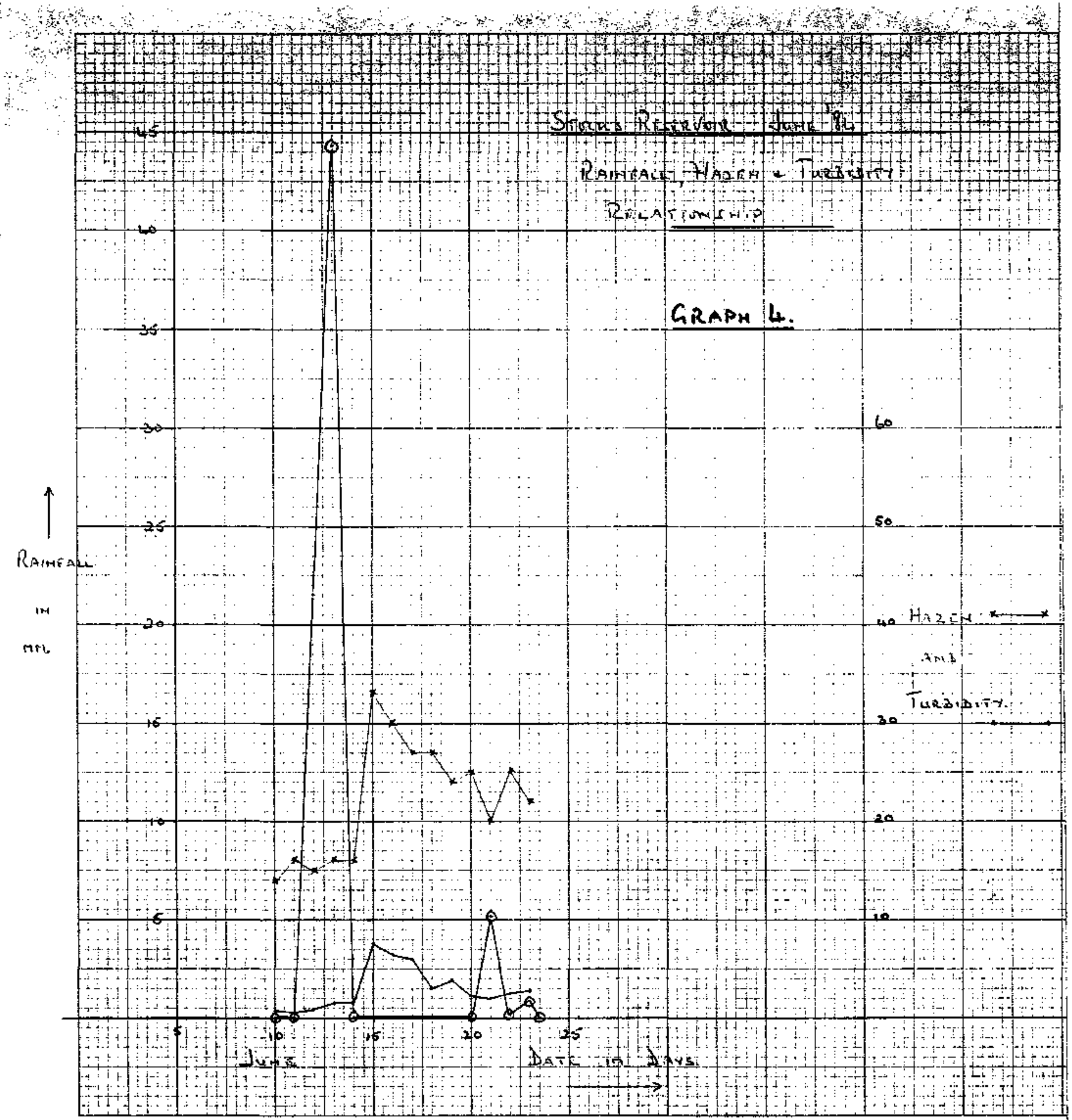
Fish taken from the screens and stored frozen were analysed by a bibiologist at a later date. The stomach contents were of prime importance and showed that the fish had been feeding in mid water with few benthic invertebrates in their diet. The presence of bullheads, bottom living fish, showed that the lowest draw off port was receiving some fish. However, the number of fish feeding primarily on Cladocerans, pelagic zooplankton indicated that mid water feeding had exposed the fish to being drawn in from the middle port. At the time these fish were collected both the bottom and middle draw off ports were open.

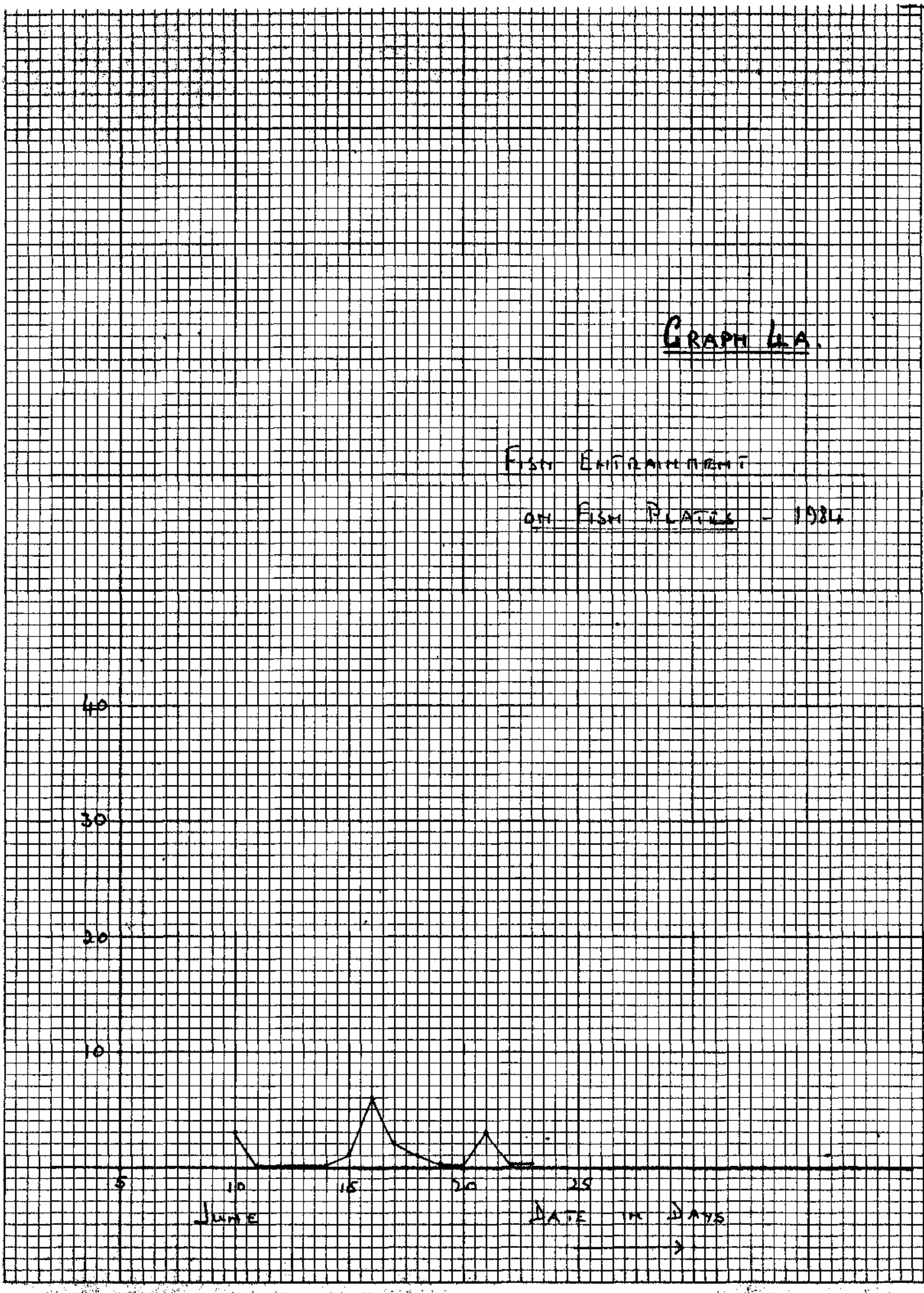
Physical and environmental factors affecting fish ingress

Graphs 2 and 2A. show that over the past 8 years there has been a relationship between the draw down level and the numbers of fish collected on the screens. Quite obviously the density of fish is increased, the lower the reservoir goes but there is not a directly proportional relationship between the volume of the reservoir and the fish lost. Graph 3 shows this in that this years fish losses were amongst the lowest up until August 20th. At this time the reservoir had a capacity of 3,000 Ml. and had been dropping from 4,000 Ml. for the previous 3 weeks. 1983 was the only year in the past 8 when the capacity dropped below 3,000 Ml. Yet every other year had greater losses than this years up until August 20th. Except for 1979 and 1980 when the lowest annual capacities were only about 6,000 Ml.

The area of the reservoir on August 20th was about 90 acres which would give a fish density of about 62 lbs./acre. This is a relatively high fish density and yet throughout August up until the 20th very few fish had been drawn into the plant. The draw off rate at this time was 50 Ml/d which was greater than any rate for the previous month and greater than the following 2 weeks, which average at about 45 Ml/d. Consequently the draw off water velocities into the pipe were higher than average at this time but did not draw in extra fish.

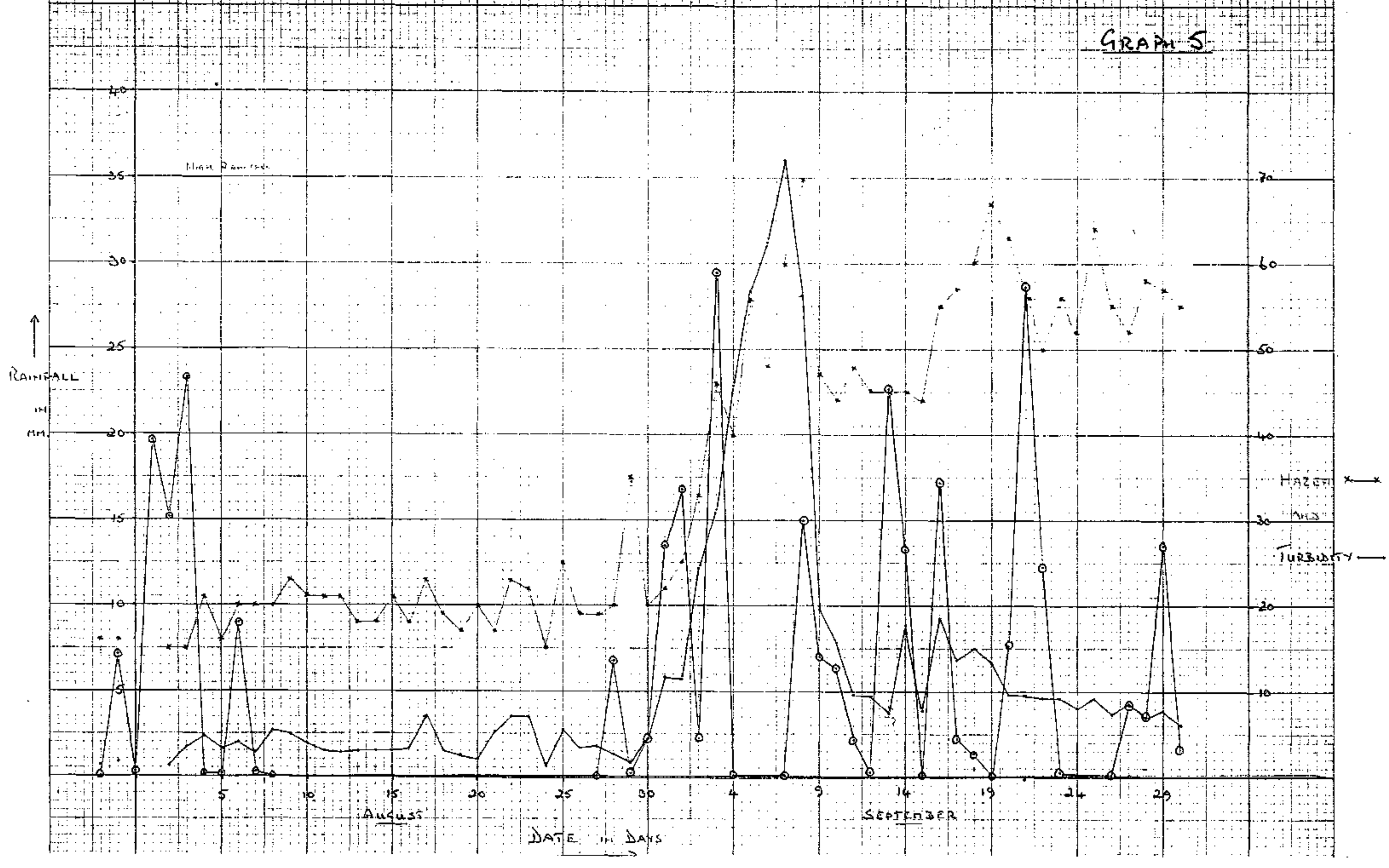
Water quality could have a significant influence on fishes behaviour and so the hazen and turbidity were studied in detail for 1984. Graphs 4 and 4A show the relationship between rainfall and hazen and turbidity at Stocks. The very heavy rainfall on June 13th, 1984 resulted in an increase in turbidity and hazen but not sufficient to produce a lot of fish on the fish plates. However, there is partial correlation between the time of fish entrainment, turbidity and hazen. This is much more pronounced in Graphs 5 and 5A. where the relatively heavy rainfall of September 3rd produced a significant increase in turbidity and hazen.


Rainfall, Hazen + Turbidity
Relationship
GRAPH 4.
Rainfall
in
mm
Hazen
and
Turbidity
June
Date in Days
45
40
35
30
25
20
15
10
5
60
50
40
30
20
10
5
10
15
20
25

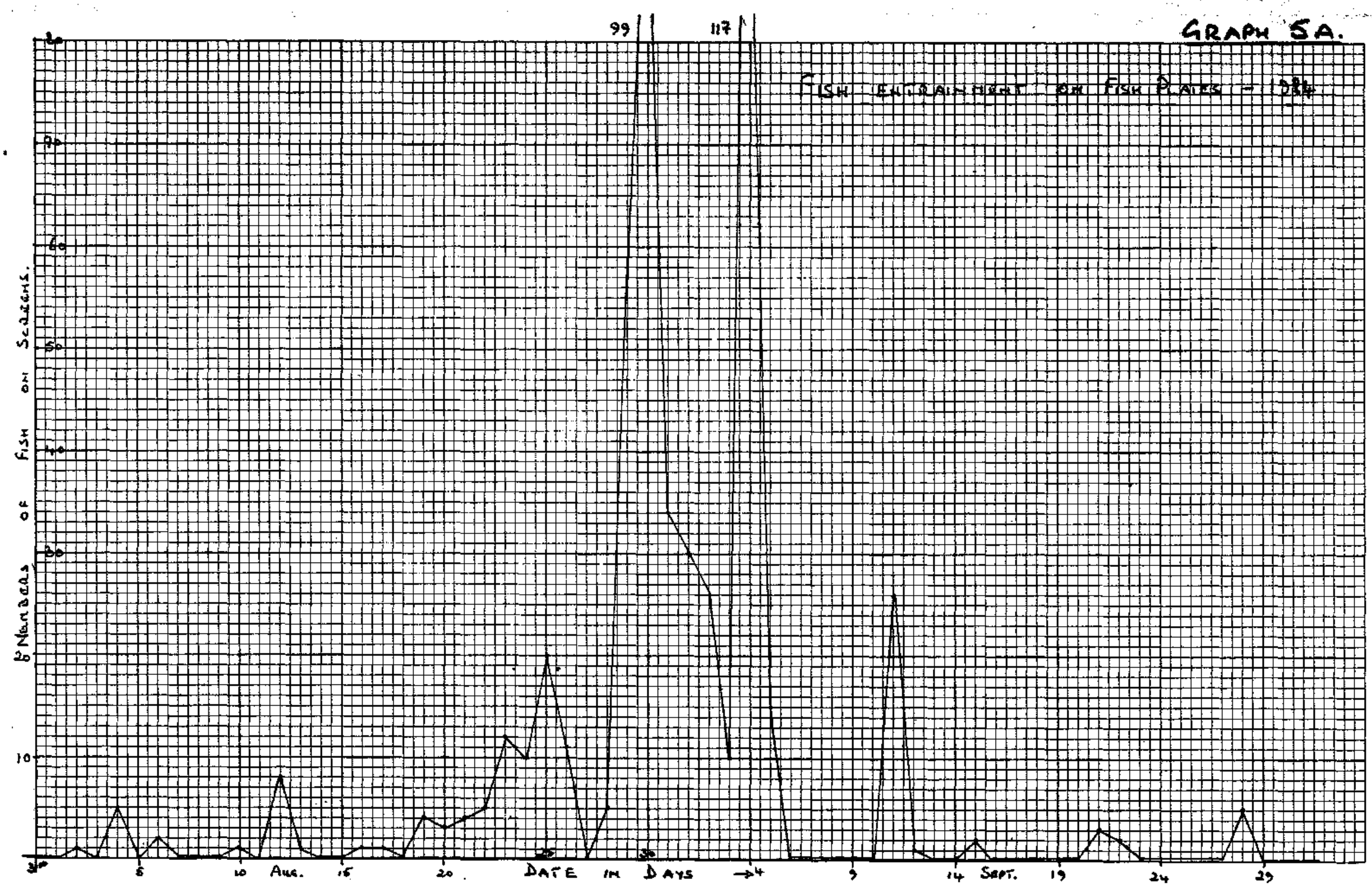

GRAPH 4A.
FISH ENTRAINMENT
ON FISH PLATES - 1984
40
30
20
10
5
10
15
20
25
JUNE
DATE IN DAYS

Stock Reservoir – Rainfall with Resultant Hazen & Turbidity in Plant

Graph 5



GRAPH 5A.



FISH ENTRAINMENT ON FISH PLATES - 1984
99
117
NUMBERS OF FISH ON SCREENS.
80
70
60
50
40
30
20
10
31
5
10
AUG.
15
20
25
DATE IN DAYS
30
→4
9
14
SEPT.
19
24
29

The hazen is seen to respond sooner to the rain of the previous 5 day's, as would be expected, but the turbidity responds to the heavy rain of the 3rd. The area of the reservoir was about 80 acres whereas on June 13th it was 140 acres and even with 45mm of rain in June as opposed to only 30 mm in September the additional area and volume of about 2,000 Ml prevented severe turbidity and disturbance of fish from reaching the draw off tower.

The rainfall of early August did not create sufficient turbidity disturbance to cause fish to move and consequently no fish were taken. However, the fish loss peaks of August 25th and 30th do not coincide with any shift in turbidity count. The same applies to the fish peak on September 11th which comes well after a rainstorm on the 8th. Hazen and turbidity on the graphs are measured from the raw water, the draw off water to the fish plates. This water is at a particular depth possibly near the surface if the upper draw off is being used. Hazen and turbidity figures are available for the compensation water which is the very bottom water of the reservoir. If the fish are being disturbed and drawn into the valve tower by poor bottom water quality then the compensation water may show this. Table 5 shows the difference between the raw and compensation water quality. For the fish peak on August 30th there was no significant difference between them, nor was there on the 25th but on September 7th and 8th the compensation water had dropped in turbidity far more than the raw water. This does not explain the fish peak on the 11th but it does signify that a difference in turbidity does exist with depth. If water quality at the head of the reservoir deteriorated, fish would be forced down to the dam, ahead of any turbidity plug which may not reach the draw off tower. No such evidence is available for both fish peaks on August 25th and 30th, the latter one being a fish loss of considerable consequence.

Fish loss by way of the overspill or compensation/scour valve does not affect the operational practices of the treatment plant, as do the fish plates. However, there is a potential in both routes for a loss of stock fish. Neither source could be assessed in this study but the potential loss from the waterbank compensation needs attention. The normal compensation of 3 or 4 m.g.d. does not produce sufficient velocity of water drawn into the 36" pipe to aid loss of fish. There is a possibility that the spring and autumn downstream migration of brown trout may be attracted into the scour pipe but it is more likely that they would go down the supply draw off, the velocity of which is much greater.

COMPARISON OF WATER QUALITY FROM

RAW AND COMPENSATION WATERS

Date 1984	Raw Water		Flow to Supply Mld	Draw off Valves	Compensation Water	
	Hazen	Turbidity			Hazen	Turbidity
4th September	40	45.8		Middle	23	17.5
5th September	56	56.8	55	Full open Bottom open 7"	66	72.8
6th September	48	62	36.64	Bottom open 9"	40	90
7th September	60	72	33.38	"	37	29
8th September	70	52	34.60	"	40	29
9th September	46	19.6	34.27	"	45	20
10th September	44	15.8	34.00	Middle full Bottom open 9"	54	12.2

N.B. Raw water is from relevant draw off inlet on tower. Compensation water is from the scour bottom water.

Note the significant delay in turbidity being increased in compensation water and how it clears 2 days before the top raw water.

The velocity of the waterbank is of greater concern as 50 m.g.d. down a 36" pipe would give a velocity of 3.29 metres/sec. This is likely to be experienced four times a year, however, this year it was not utilised and so the loss could not be assessed.

Plant Operations Analysis

Routine fish plate maintenance requires that each of the 22 plates are unbolted, taken off and the pipe checked for fish ingress weekly. At 25 minutes bonus time for each plate the manning requirement would be in the region of 9.2 hours weekly. When there is a severe ingress of fish which may happen on average only once or twice a year the fish plates could be cleared for 2 or 3 shifts by a number of operatives in order to maintain supply pressure. No extra labour is taken on for this operation but the inevitable drop in supply pressure occurs. On September 6th it dropped from 55 Mld to 34 Mld. Yet it is noticeable that this is operationally desirable due to the high turbidity of the raw water at the time. On August 30th during the first big ingress of fish the turbidity did not increase and the flow to supply was maintained at 40 Mld despite the fish problem.

If the fish plates are to remain the first line of defence against fish entrainment then the total cost of manning and time spent needs appraisal. On the assumption that the cost is unacceptable in future and that greater fish entrainment will cause more operational problems, a less time consuming way of clearing the fish plates has to be considered. If the bonus time of 25 minutes was reduced to 5 or 10 by redesigning the fish plate fastening, the inconvenience, whether money or disruption to supply, would be more acceptable. Instead of fastening the fish plates with eight hexagonal nuts a quick release clip fastening or similar device would substantially reduce the bonus time and allow fewer personnel to man the plates on days of fish overload.

The size of fish is critical to the pressure drop across the filter batteries. Yet due to constantly altering variables such as head of water and flow rate to supply the effect of a large or small fish on the plates varies considerably. One large fish may cause sufficient pressure drop to stop a battery whereas a number of small fish will be required on the same plate. Yet if the temperatures are high and the supply flows high the small fish disintigrate faster than the large fish.

Screening of the valve tower draw off ports will obviate the need for additiondl works to the fish plates which will only become a second line of defence. In order to effectively make the fish plates redundant it would be necessary to cover all of the draw off ports with a screen sufficiently fine to prevent nearly all sizes of fish from entering. This would require a metal grid structure of vertical bars set no more than ½" apart. This spacing would prevent the ingress of any fish that would cause an operational loss of pressure across the battery of filters. A spacing of ½" would exclude the bullhead species of bottom li.ing fish as well as most fish over 4 to 6 inches in length. The smaller fish recorded were in this size range. The metal screen would be sufficiently fine to block if trash were a common problem but it is not known to be at Stocks. The screen would have to be rakable and an automatic raking system, electrically w.rm driven from the valve tower house would be necessary, extending down the exterior wall to all three draw off points. If it was decided to only fix the lower 1 or 2 screens the cost (Table 6) would be reduced but not proportionately. This is because the majority of the diving costs are for site preparation.

An alternative method of physically screening the ports would be to surround the whole tower with a net (sample displayed). The net would have to hang from a securing collar just above the top port, or the overhanging buttress of the valve tower. The total depth of the net would then be respectively about 58 feet and 80 feet and have a diameter of 20 feet. The net would have to be kept away from the draw of water into the ports by means of hooping the net in the vicinity of the ports. At 20 feet diameter the hoops would hold position in the corners of the tower and keep the net about 1½ feet from the port. At this distance the water velocity into one port receiving 50 Mld would be in the order of 1.5 M/S, which is not excessive. Due to the area of the netting there should be no problems with blockage and as the net is free hanging it can be raised relatively easily for repair and inspection.

A compromise screening that may be considered for visual reasons, in preference to the fixed net could be a floating net collar. This would effectively screen any two ports at a time if it were 45 feet deep, at a maximum. At top water level this would reach 6 feet below the middle draw off and as the bottom draw off was utilised, with decrease in water level so the net would cover that port as well. Inspection, repair or even replacement would be easy but the method by which the floating collar rides up and down the tower would need careful design,

Appendix 4

Table 6

VALVE TOWER SCREENS

COMPARATIVE COSTINGS

- approximate, relative to savings.

(1) Steel Grid Screen

Screen design & construction	2,000
Automatic valve mechanism	4,000
Installation & diving costs	7,000
	£13,000

(2) Net collar - full heights fixed

Net - 80' x 20' dia.	750
Securing fixtures	1,000
	£1,750

(3) Net collar - floating $\frac{1}{2}$ height

Net 54' x 20' dia.	450
Float collar, guides on tower & sundries	2,000
	£2,450

(4) Windermere Pumping Station Fish Screen

Approximate cost at 1981 prices

Departmental design & construction of pulsed D.C. fish screen unit	7,000
Installation & diving costs	11,000
TOTAL	£18,000

Note: (1) Diving costs are less generally nowadays.
Diving team of 4 cost £350 to £450 per day.
1 mans work in 2 hrs. on surface ≡ 4 divers at 60' for day.

Continued.....

(2) Cable run from shore was of high grade cable for 300 metres.

(3) One pulsed D.C. unit could power 3 screens at Stocks but 3 intruder grids would be extra.

(5) Chemical barrier

Hemispherical metal pipework x 3	3,000
Pump & header tanks	1,000
Installation & diving costs	5,000
	£9,000

as would a method of preventing the net being sucked in at varying heights. A good seal at the bottom would not be simple because as seen in the plans the ground is not flat. The slope of the dam pitching may prevent a good seal even on a leaded net and as the bottom draw off is only 1 foot off the pitching fish ingress could be anticipated.

The final methods of screening fish out of the draw off ports are not physical and therefore require there to be a deterrent at a distance from the pipe that will turn the fish away from the inlet before they get drawn in by the velocity of the water. The only possible deterrents are electrical and chemical, both of which fish are sensitive to, any sound deterrent having to be low and loud enough to possibly cause damage to the valve tower.

The estimated velocity that exists at the entrance to the 24" inlets is in the region of 2.7 metres/second. Due to the 21" valves being so close to the bellmouth it is considered that this diameter fixes the velocity and in this instance the inlet flow is 50 Mld. This flow is the anticipated maximum take off from the lowest inlet when the reservoir is right down. At increased levels two inlets would generally be in use and even at maximum flows of 130 Mld each inlet would only be 15 Mld more.

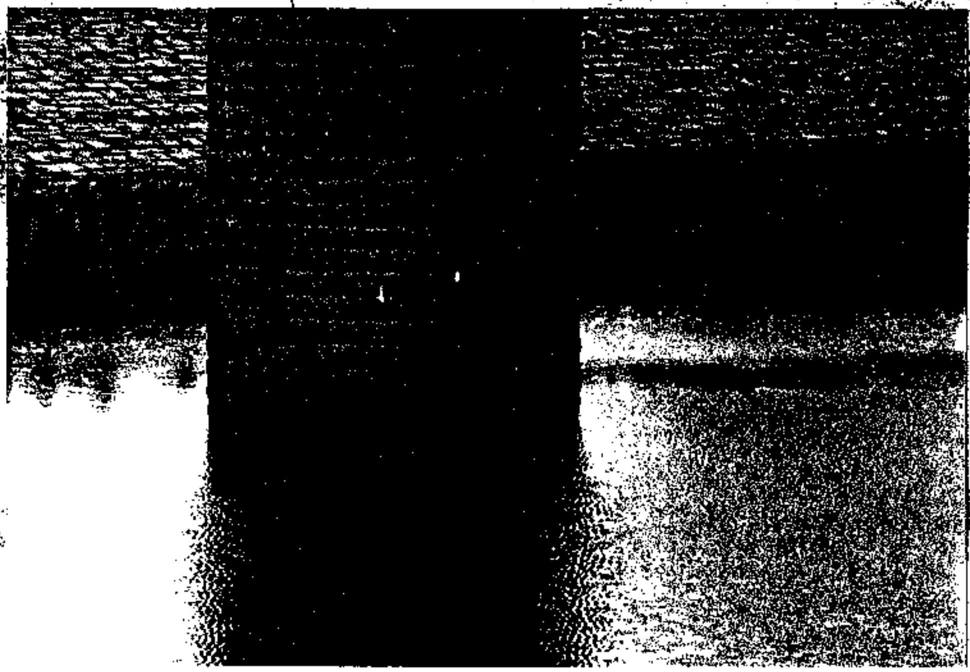
If the maximum velocities in the inlet are about 2.7 M/S then three feet out from the inlet, on the edge of an imaginary hemisphere, marked red in diagrams 2 the velocity would be 0.46 metre/second. At 6 feet out, on the green line, the velocity would decrease to 0.12 metre/second. This velocity is considerably reduced and quite acceptable for a small fish to swim against. Effectively a 4" to 6" fish would have to swim at one body length per second to combat this velocity. Fish can comfortably swim at ½ to 1 body length/second and when in "flight or fright" they can swim at between 6 and 8 body lengths per second.

Electrical fish screens are a means of deterring fish at a distance and this method is in use at Windermere pumping station where a pulsed D.C. electrical unit gives fish, in the vicinity of the intakes, an electrical impulse. The layout of the Windermere system is shown in diagram 3 and the same system could be utilised at Stocks, given various modifications. These modifications would depend on the design criteria for electrical field at distance from the pipe and velocity of the water. The velocities catered for at Windermere are less than those at Stocks with 86 Ml/d being drawn into 2 x 36" pipes. The siting of the electrodes within the pipe are for health and safety reasons, however sufficient electrical field extends

STOCKS RESERVOIR.

DIAGRAM 2.

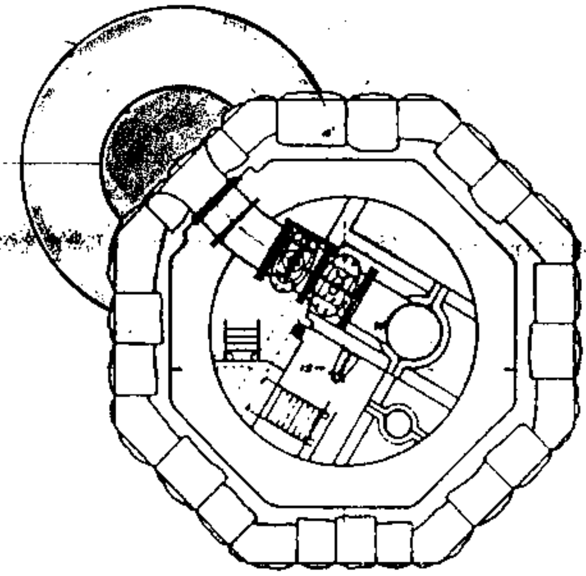
VELOCITY GRADIENT ON DRAW OFF PORTS.



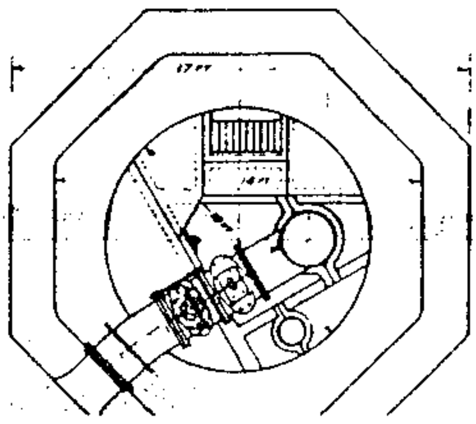
AT 50 Ml/d FLOW

6' RADIUS
0.12 M/S.

3' radius
0.46 M/S.



SECTIONAL PLAN AT
No 3 DRAW OFF



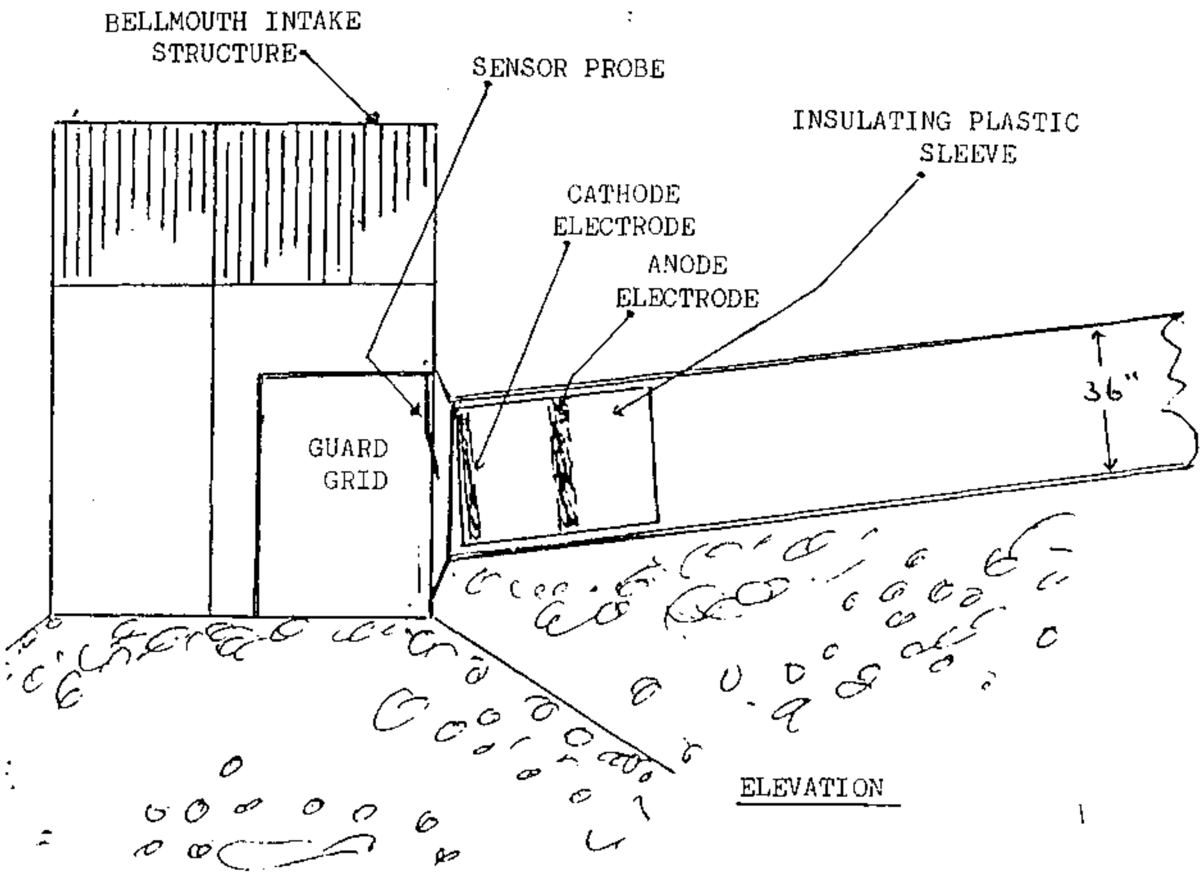
SECTIONAL PLAN AT
No 2 DRAW OFF

DIAGRAM 3.

WINDERMERE PUMPING STATION INTAKE

GENERAL ARRANGEMENT OF FISH BARRIER

ELECTRODES AND GUARD GRID



ELEVATION

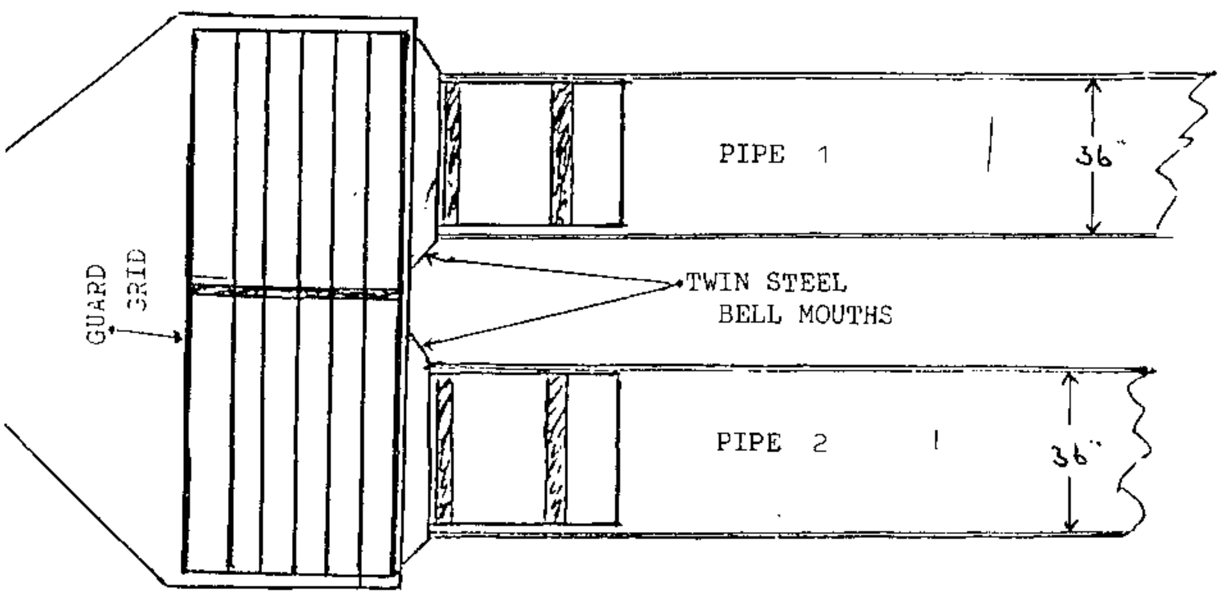


FIG. 1

PLAN

2 to 3 feet out into the bellmouth area to deter fish. The design criteria for this installation was to have a deterring electrical field at a distance from the pipe where velocities of between 0.5 and 1 feet/ second exist. This velocity was at 2 to 3 feet out and so for the given power of the pulsed D.C. unit this could be obtained with the electrodes within the pipe. At Stocks this velocity will exist at 6 feet from the pipe therefore it will be necessary to site the electrodes out from the pipe or increase the power.

Health and Safety requirements were seriously considered at Windermere and a guard grid was constructed to cut off the current if the grid was entered. This intruder device is able to sense a drop in electrical potential between the grid and the sensor probe, (see diagram) if a spear or the likes is pushed in towards the electrodes. This structure poses no blockage of flow threat to supply. The approximate cost of the electrodal installation is listed in appendix 4 .

A chemical barrier would need to have the same deterrent effect at the desired 6 feet from the inlet as the electrical barrier. There would need to be a hemispherical pipework grid, 6 feet out from the inlet capable of injecting chlorine into the water. The basis of this design is that prechlorination is carried out at about 1 to 0.5 mg/l on the inlet to the plant in order to treat excessive organic matter prior to filtration. Chlorine at Stocks is injected after filtration on the outlet to supply at a concentration of less than 0.5 to 1 mg/l. Consequently some of the chlorine for pretreatment would be available for post-treatment after the water has gone through the filters. Prechlorination will not have any adverse affect on the aluminium sulphate or polyelectrolyte, which are flocculating agents injected into supply between draw off & filtration. Prechlorination can produce taste problems if used in sufficient concentrations with excess organics, that produce phenols. This is not anticipated at Stocks as the levels are well below those that produce a taste problem.

Avoidance behaviour of salmonids to chlorine is at concentrations of 0.001 to 0.01 Mg/l, 100 to 1,000 times less than the normal prechlorination concentration. Therefore, the dosage into the hemispherical area of draw off water to the inlet is not critical and a framework of tubes set 1 foot apart injecting chlorine in at a preset concentration would create a barrier. The supply of chlorine to the tubed framework would have to be from a header tank situated in the valve house and injected or fed by gravity down to each framework, set around each draw off pipe. Rates of injection would have to be set depending on the draw off level in use and the rate of flow. The cost of such an installation is not available but due to the nature of the system with header tanks, supply pipes and framework it is not expected to be very great.

DISCUSSIONS

Fish Stocking

The initial stocking with rainbow trout in March did not unduly affect the overall density of fish in the reservoir but immediately after stocking the density of fish in the dam area of the reservoir was significantly increased. With a temporary increase of 28 lbs./acre ontop of the indigenous population, estimated to be 10 lbs./acre, the density of nearly 40 lbs./acre was substantial. However, it has been seen that no stock rainbow trout were taken on the fish plates for 3½ months after stocking. The reliability of species identification at the treatment plant should be good as the operatives were used to handling the fish and all fish were checked by fisheries staff. The brown trout losses on the fish plates were increased after stocking for 11 days which is similar with previous records but past data have not differentiated between species and also it has not been able to say where stocking took place. The influx of brown trout indicates that the stock fish disturbed the territory of the brown trout thereby causing them to move about and increase their chance of going close to the draw off tower. Such territorial disturbance is in keeping with known effects of interspecific competition.

The second stocking in July produced no significant increase in fish on the plates even though this stocking produced a temporary density of 70 lbs./acre. It is significant that an increase of fish does not force a number of fish into the draw off pipe nor do stock fish have any preference to follow the flow out of the reservoir. As to why the 70 lbs./acre of stock fish did not disturb the native fish is not understood other than to propose that seasonal migration within the reservoir produces a greater density of small native fish near the dam early in the season.

Anglers Returns

The post paid anglers returns this year were 219 in total with 34 of these nil returns, at 15.5%. The number of returns were less than the three previous years on record with 343 visits in 1977, 233 visits in 1978 and 251 in 1983. The decrease this year is believed to be due to a decrease in members interest in Stocks with the ceasing of the clubs lease. Therefore the low number of returns is fairly accurate as the nil returns are a satisfactoy percentage and it is known that regular club members are generally more reliable on returns than day ticket anglers, (Crisp and Mann, 1977).

The percentage return of adipose clipped rainbow trout was very low at only 11.87% of the stocked population. This is however in keeping with the 1983 returns where about only 10% of stock fish are estimated to be recaught. The percentage return on Draycote Water was considerably higher averaging 67%, (North 1983) and at a much smaller fishery Toft Newton the recapture rate was 69% (Coles 1981), whilst a percentage of catch per stock for 8 upland reservoirs average over 80% for rainbow trout (Crisp and Mann 1977). The low percentage recapture for Stocks reflects the anglers visits which are a relatively small sample number. In estimating the standing population of the reservoir it is the proportion of rainbows to browns caught that is critical so the small sample size holds for this principle. The assumption that brown trout are as easily caught as rainbows has to be made, yet it is often not believed to be the case, as at Draycote Water where 78% rainbows and 44% of browns were recaptured, (North 1983). Yet it has been known for brown trout to fish as well as rainbows especially where the populations are low and of similar size. The number of undersize fish returned is an underestimation of the total population as angling is selective for larger fish, (Crisp and Mann, 1977), and it was also seen in this study that the numbers of undersize fish lost to the screens was greater than the larger size of brown trout lost. This was however, selective in itself for smaller fish. Subsequently it is considered that the population estimate is on the conservative side, but the biomass of a lot of small fish would not alter the total biomass unduly. The resulting biomass of native brown trout at 8.6 lbs./acre (0.86 g/m^2) winter level, is what would be expected from an oligotrophic lake. However, with the addition of the stock fish at low reservoir levels, with acreages of less than 100, a fish density in excess of 90 lbs./acre existed.

It is postulated that a temporary high density of fish existed near the dam after stocking. This could have been for a few days but dispersal is seen to be quite rapid and in Scottish locks it has been seen from sonically tagged fish that widespread movement after stocking, with half a mile travelled in the first 4 hours is to be expected, (Phillips,1984). Anglers returns from the head of the reservoir after a few days agreed with this. Analysis on the favoured beats and areas of the reservoir where rainbows or browns are best caught indicates that the rainbows were present in the dam end more than elsewhere. The middle area of the reservoir was quite successful for rainbows and browns with brown trout fishing best at the head of the reservoir. The indication that rainbows held in the lower and middle regions of the reservoir has not made their numbers any more susceptible to entrainment into the draw off intakes.

The success of rainbow trout catches for only the month after stocking is consistant with the belief in regular stocking and Draycote Water found that 90% of fish were taken within 45 days of stocking (North 1983). The catch per unit effort was high compared with 1983 and other fisheries, primarily due to the success of the rainbow trout catches. The catch per visit data could be biased by the lack of nil returns sent it. On Ffestiniog fishery it was calculated that just over 50% of anglers had nil returns, (Cane, 1980) which is 35% more than the nil returns in this study. This fact does not affect the overall population estimate and the catch/visit figures are only analysed on a monthly comparative basis, not with other fisheries.

Treatment Plant Fish Plates

The extremes of conditions this year have exagerated the results very satisfactorily this being initially seen in the results of fish lost up until August 19th. Only 150 fish had been lost up until then and yet the level of the reservoir was nearly down to 3,000 Ml. In the two comparable years of 1979 and 1980 the reservoir did not even go below 6,000 Ml. Therefore there is no direct correlation between reservoir level and fish entrainment onto the plates, although there is the indirect correlation of low reservoir levels producing other factors that cause fish losses. ?

From the species and size data of fish inspected off the plates it is evident that stock rainbow trout do not have any specific tendancy towards entrainment into the draw off tower. With only 2.8% of fish lost being rainbow trout they could be showing a positive reaction against the draw off because 47% of medium and large brown trout were lost to the plates. If there was a size preference for fish loss, based say on swimming speed it would be expected that large rainbow and brown trout would have the same % losses. This assumption is made on the basis that the populations of brown and rainbow trout are about the same, as calculated, and that they have similar preference for the dam end of the reservoir. It is possible, as postulated that the brown trout population is greater than conservatively proposed but not as much as these losses propose. For example if the brown trout population was 10 to 15 times greater than the stocked rainbow trout the biomass of the reservoir would be nearly 12 tons of fish. This would give a winter standing density of 76 lbs./acre which is not possible.

Small fish are significantly more likely to be drawn onto the fish plates than larger fish. This is most probably due to their inability to swim against the velocities of water being drawn into the plant. The velocity of a fishes swimming speed is directly related to the square root of its length, all salmonids having roughly the same coefficient of swimming velocity, (Nikolsky 1972). With this square root relationship juvenile fish can swim at peak rate quite fast but not as fast as their seniors. The total estimated biomass of small and medium brown trout from anglers catch was not of the same proportion as the fish on the plates. Both methods of capture are selective in their own way and therefore a correction to the estimated biomass could be appropriate as it could be an underestimate.

The pressure drop on the filter batteries caused by fish entrainment occurred on a variety of batteries. Although the pattern of preferential entrainment is fairly consistant the reasons for this are not clearly understood. This line of research has not been pursued as it is of little operational value. Had batteries 19 to 22 been continually blocking remedial action could be suggested but no reasoned pattern could be seen in the existing blockages.

Stomach content analysis from the few fish drawn into the plant towards the end of the study was of interest. During the sample period both bottom and middle draw off levels were being utilised and this is reflected in the types of food organisms in the trout stomachs. Most of the food organisms were adult insects or zooplankton implying that these trout came in via the middle draw off port and yet 28 small bullhead were also sampled over the same period. These were almost deffinitely drawn in via the lowest draw off as this species is a bottom living coarse fish of riverine habit. Its presence in the reservoir especially at depth, is unexpected and can only be attributed to the rain storms earlier washing them out of the rivers and becks upstream.

The diet of the small trout contained mostly Cladecerans whereas the larger trout had adult insects ingested. This indicates a difference in feeding habit, as is to be expected, but does not show a difference in feeding location. It is widely known that rainbow trout when stocked into a water distribute the brown trout out into deeper water, (Phillips '84), but the data here does not support this. Yet when the rainbow trout were stocked in March they did disturb the brown trout and cause a larger "take" on the fish plates. Brown trout do generally prefer the littoral feeding zone and yet throughout this study they are seen in the vicinity of the deep water draw off tower whereas relatively few rainbow trout were recorded. There is evidence that rainbow trout eat more deep water chironomids than brown trout (Brown et al, 1979) and if this is the case there could be serious implications for the future. However, the diets of these two species of fish are broadly the same and their respective niches in the future will depend upon the availability of food. It is known that brown trout consume more fish food than rainbow trout (Idyll 1942), with larger brown trout consuming nearly 30% fish by total volume (Phillips 1984). This could significantly reduce the small fish entrainment into the fish plates in future which in this years study accounted for 57% of lost fish.

Physical and Environmental factors affecting fish ingress

The unusually early draw down of the reservoir this year produced considerably reduced volumes and resulting area by July. It has been seen that very few fish were lost up until August 20th and with a relatively heavy density of fish in the reservoir after July 24th, of 62 lbs./acre, on August 20th fish loss cannot be correlated primarily with fish density.

Turbidity and hazen have been identified as primary causative factors for fish ingress into the draw off tower. On the two occasions this summer when the reservoir level increased, June 14th and August 31st, the rainfall produced a significant increase in turbidity and hazen. However, in June when the rainfall was more severe than August the hazen and turbidity did not increase due, it is proposed, to the buffering of a reservoir capacity of 4,700 Ml. Insufficient data available from the top end of the reservoir to be able to say what the hazen and turbidity was like furthest from the dam. Water quality does however, vary with depth as seen by the raw and compensation water analysis. High turbidity and hazen counts do produce severe ingresses of fish but the significant loss on August 30th was partially inexplicable as the rainfall, and hazen increases were negligable and turbidity change average. Recent investigation has identified the possible cause for fish losses on August 22nd to 25th. Appendix 5 shows that the wind strength was significantly greater than average. It is postulated that wave action at the head of the reservoir produced turbidity increases at that location sufficient enough to force fish to move down towards the dam in the clearer water. The turbidity need never have reached the draw off if it was mostly colloidal silicates, and not humates, that would readily settle out. If on the 25th the fish were generally disturbed, then the light rainfall on August 28th, which increased the hazen but not turbidity, would have pushed a far greater concentration of fish into the dam area. See Appendix 5A.

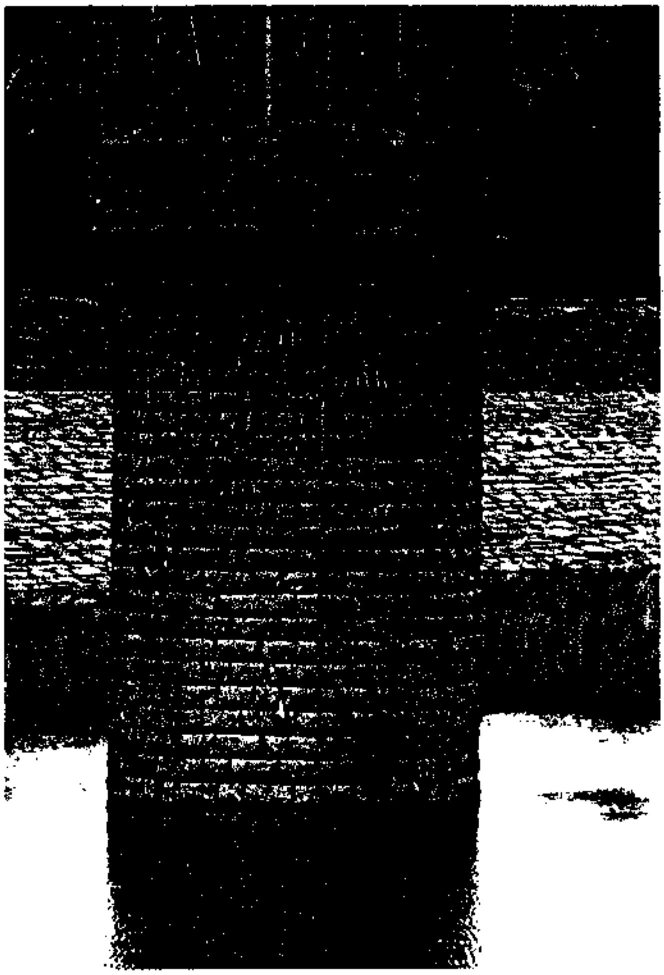
No alterations in flow regimes through the plant at this time could have accounted for these fish losses and so it is significant that increases in turbidity and hazen can cause disturbance of fish sufficient to concentration them in the vicinity of the dam, with subsequent loss to the fish plates. The fish losses however, cannot be solely correlated with rainfall as there are other variables that cause turbidity such as wind speed. The severity and locality of rainfall is relevant as is the direction of the wind. It is generally known that a population of fish can be disturbed, as a whole, by a change in conditions. Such an instance is the disturbance of a coarse fish population when stocking a lowland reservoir with game fish, as is seen at Rutland Water where coarse fish are lost on the fish screens at game fish stocking times. This reaction is seen to be only an initial response and transitory. Similarly at Stocks the fish are disturbed and forced away from the dirty water at the head of the reservoir. Yet the fish become acclimatised to the change in the water quality and did not react to the poor water quality caused by heavy rains after September 11th.

Fish loss direct to the River Hodder by way of the waterbank/scour pipe will not affect operational efficiency. However at calculated water velocities of over 3 metres per second it is considered that stock fish will be lost from the fishery. This can be monitored in future when the waterbank is in use.

Plant Operations Analysis

The routine fish plate clearance costs the Authority about £2,500 annually. Additionally there is the manning in times of severe fish ingress which would cost between £500 and £1,000 exclusive of operational inconvenience. Therefore a total of £3,500 for fish plate clearance could be reduced by about 1/5th if a simpler design of fish plate fastening were installed. Design and installation would be in the region of the present annual manning costs but the long term benefits would be unquestionable. If however, the fish plates are not the only screening device and the valve tower is screened then there will be no need to alter the fish plates. Nor should there be a need to check them weekly, if at all.

The pressure drop across the filter battery is dependent upon whether the fish on the fish plates are large or small. Multiple small fish have the same effect as a single large fish. In future is is believed that the number of small fish available to be drawn into the filters will be far less. Therefore if the present system continues fewer random small fish will be cleared but when large fish are drawn in the situation could be worse than at present.



Screening of the three draw off inlets on the valve tower would make the fish plates effectively redundant. The classic screen used for most water intakes are metal grids fixed over the aperture. The spacing of ½" between grid bars would be essential to stop most of the small fish being drawn in. Extensive literature and practice determines that this is the usual criteria for salmon smolts of 4" to 6" in length. The problem with a fixed screen is blocking and although automatic raking can be provided, and debris is minimal at Stocks there is always a possibility, especially with plastics and the increased recreational use of the reservoir. The most vulnerable situation would be when the reservoir was as low as this summer and water could only be drawn from the one draw off.

A full height net surrounding the valve tower is a practical proposition and one that has been successfully put into operation at the only other site in the country where this fish entrainment problem exists. Extensive enquiries throughout the U.K. have only brought to light this one site at Kennick reservoir in the South West. A number of fish were being drawn into the filter shells from the reservoir (45 acres stocked with 10,000 fish for a rod return of 1 to 1.5/rod/ day), the treatment plant not having any fish plates. Taint problems were resulting and costing £2,000 to remedy by renewing the filters. A net collar of 1¼" kk 28 feet deep hung on the 8 foot diameter valve tower from 10 foot radial arms, stretched the full height over three inlets. It was heavily leaded at the base. The apparent success of this net was its rigid set, hung well out from the tower. Stocks valve tower at a minimum height of 58 feet to just above the top draw off is considerably higher than Kennick. The cost of materials at Kennick was approximately £1,000, which is in line with the estimates appendixed.

The proposals to use an aesthetically acceptable floating net that by definition is always below the water surface and thus out of sight is fraught with operational problems. A free floating net would be inclined to get drawn into the inlets and may not provide a good seal on the bottom. At Kennick they decided against this option but a well designed sliding net collar should theoretically be as efficient as any screening device.

Physical barriers if fine enough, are a definite way of stopping any fish entering an intake. Electrical barriers likewise deter fish from coming near the inlet but if they are not operated at the design criteria or some factor is overlooked, then the inlet is fully exposed to an ingress of fish. Infact an electrical screen can assist in drawing fish in by stunning the fish and drawing it in whilst in a state of tetanus Windermere fish screen is not operating at all efficiently at present due to one of two reasons. Firstly there is a hole in the pipe possibly drawing fish in and secondly the draw off flow is 2½ to 5 times greater than the designed criteria. Due to the drought 5 pumps at 43 Ml/d each are drawing water through 1 or 2, 36" pipe. Thus velocities are far too great in the region of the electrical field, 2 to 3 feet from the pipe. At Stocks the optimum distance out for the electrical field is 6 feet and this can be obtained by placing an electrode at a distance from the draw off port.

For Health and Safety reasons the electrode area was protected at Windermere inside a physical protection screen. At Stocks no screening at all is present and purely on the grounds of increased recreational use some sort of screen would be desirable, quite apart from the intruder device screen that shuts off the electric field. The cost of the electrical device at Stocks would be less than at Windermere because no developmental costs would be incurred and the diving charges would be less. Yet three screens would be needed which could balance out the prices. Drainage of the reservoir to enable installation in the dry, to save on diving costs, which are 50 x more expensive than on the surface work, was considered but to provide alternative water supply from the lakes would cost in the region of £1,000 per day.

Chemical barriers to deter fish are not usually considered at intakes due to the volume of chemicals required and the pollution threat to the environment, (Am. Soc. Civ. Eng. 1982). However, on prechlorinated water supply intakes this cannot be the case and in this instance, with fairly consistant draw off requirements the chlorine dosage should not be difficult to regulate. With injectable dosing the concentration could be related to flow whilst prechlorination would aid the taint problem with fish on the filter plates that Kennick Reservoir experienced. Avoidance behaviour by fish to chlorine is well documented (EIFAC, 1975) but conversly chlorine should not be a health and safety threat to recreational users in the vicinity of the intakes as seems to be the case with electrical screens.

The design of the hemispherical pipework grid to deliver the chlorine evenly will require some tank dye tests. The installation of these grids to each take off port will require divers at an equivalent cost to the electrical screen installation but the structures as a whole would be a lot simpler due to the sheer nature of their operation.

SUMMARY

1. Introduced rainbow trout are less prone to loss via the draw off intakes than the indigenous brown trout, even if stocked at a heavy density in the vicinity of the valve tower.

2. The stock fish recapture percentage by rod and line was nearly 12% which indicated that there was an indigenous population of trout with a biomass of nearly 3,000 lbs. This equates to a fish density of 8.6 lbs./acre (0.86 g/m^2)

3. Stock fish quickly spread throughout the reservoir but remained more available to anglers catch in the lower and middle reaches of the reservoir.

4. Catch per visit ratio was 3·1 and was greater than 1983s of 1·65 primarily because of the rainbow trout stocking.

5. Small fish ($<$ 8") are significantly more likely to be drawn into the valve tower than larger fish whilst large brown trout ($>$ 8") are significantly more prone to loss than rainbow trout.

6. Fish entrainment onto the fish plates is not directly correlated with fish density in the reservoir or volume of the reservoir.

7. Serious instances of fish loss on the plates occur at times of sudden and severe alteration in water quality that can be caused by wind or rain. Acclimatisation to poor water quality is evident in that fish losses are not proportionately related to the reduction in water quality.

8. Fish losses on the plates could, it is believed, be caused by any disturbance that forces the fish down the reservoir to the draw off tower.

9. Fish loss by way of the waterbank/scour is considered most likely but of no operational consequence to the treatment plant.

10. Fish plate design could be improved to increase the rate of clearing and reduce the operational costs.

11. A well designed screen on the three valve tower draw off ports would stop any need for fish plate clearing or operational problems at times of severe fish ingress. Additionally, compensation claims for fish loss would not be incurred.

12. A physical screen of either netting or metal grids are tried and tested methods of screening an inlet but their fine dimensions could cause blocking.

13. An electrical or chemical screen would not pose the threat of complete blockage to supply and either should work efficiently. The chemical screen has certain Health and Safety advantages over that of the electrical.

RECOMMENDATIONS

1. Serious consideration should be given to screening the valve tower inlets, as adverse water quality conditions in the reservoir can shoal fish near the draw off tower resulting in operational difficulties in the treatment plant. Screening is not likely to be required before August 1985 as water quality is related to draw down.

2. Further analysis of the turbidity and hazen variables at the head of the reservoir could provide a model that would predict poor water quality at the dam and assist in selecting the best of the draw off points. A study of raw and compensation water would elucidate the water body movements that additionally cause fish entrainment.

3. If the valve tower is not screened the water intake velocities should be kept to a minimum over a predicted 12 to 24 hour period whilst fish acclimatise to a change in water quality.

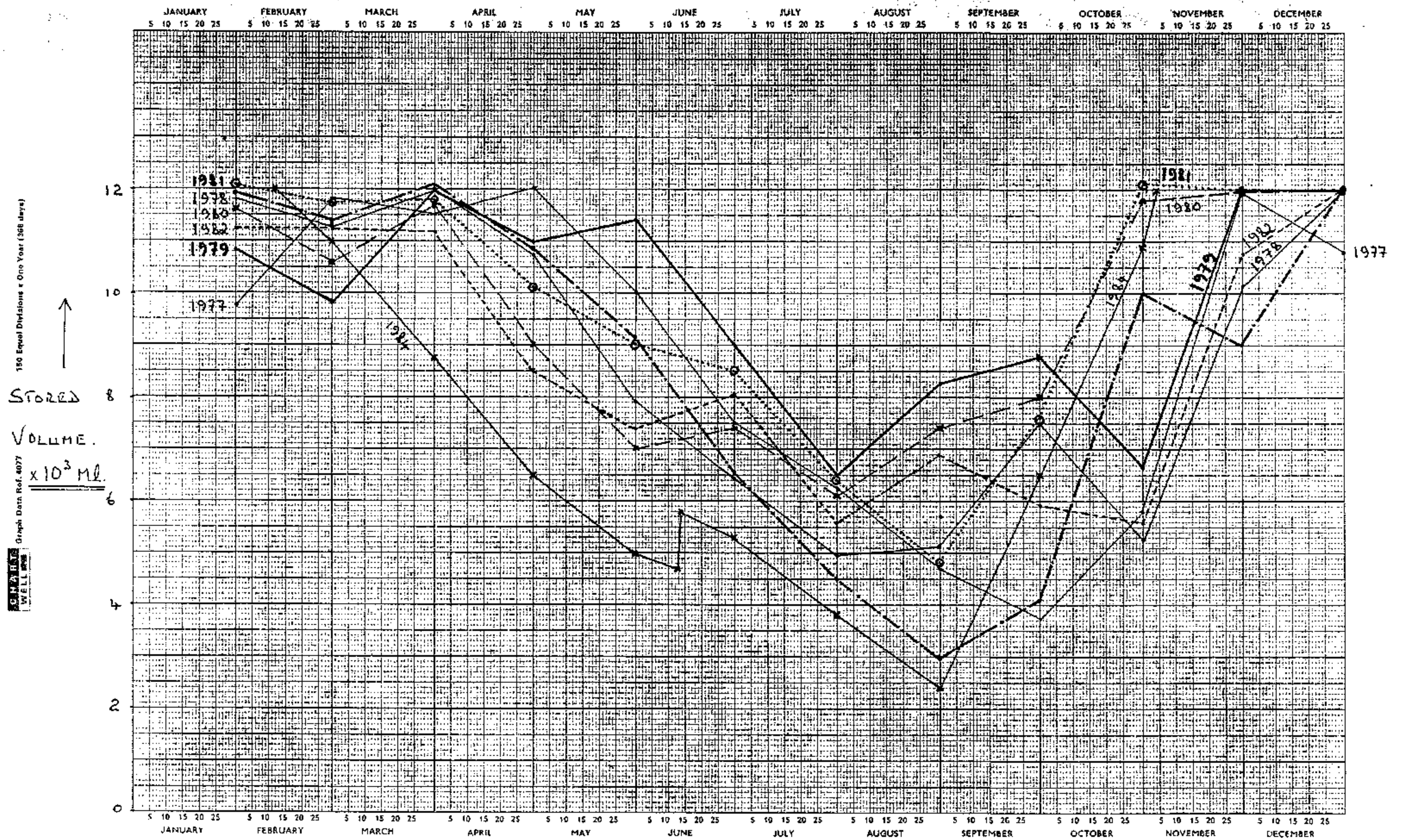
4. Continued study of fish losses on the fish plates would help resolve the species specific losses and the interaction of the three proposed species to be stocked. Additionally, losses will be quantifiable for purposes of claims for compensation.

5. Fish losses anticipated from the waterbank compensation discharge in October/November 1985 should be monitored.

6. Investigation of the rod caught fish, the stomach contents and the location of capture, with special reference to the undersized indigenous brown trout would assist in fixing the required screen size for the valve tower, as well as clarifying the interspecific relationships with the stock fish.

Appendix 1
Graph.

Stocks Reservoir   Draw Down Curves   1977 - 83



APPENDIX 2

North West Water

RIVERS DIVISION

Lancashire Area
48 West Cliff,
Preston PR1 8HP.
Tel: Preston (0772) 58133

General Manager
L. Crowther BSc Tech MICE MIWES

Our ref JEN/JB/R611/02
Your ref
Date 15th March, 1984.

All Members,
Stocks Angling Club.

Dear Member,

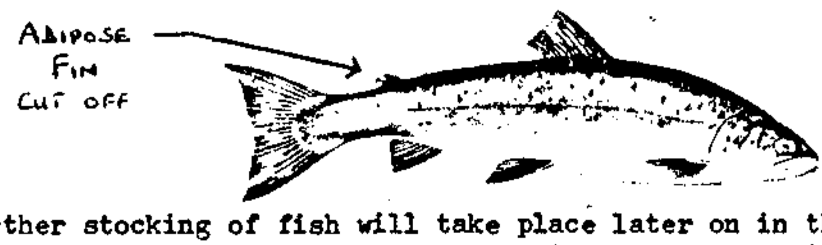
DIAGNOSTIC FISHING - STOCKS RESERVOIR

I am sure that you are aware of the proposed development for fishing at Stocks Reservoir in 1985. Tenders for the lease of the reservoir are due in by April 30th this year and the lease will run for 7 years from 15th March, 1985. Consequently, this leaves your club with the whole fishing season of 1984 at Stocks Reservoir,during which time we intend to stock the reservoir and obtain some good diagnostic fishing data.

One of the conditions of the new fishing lease in 1985 is that a stocking density of 100 lbs. weight of fish per acre, at summer draw down level of 210 acres, is required. This is a far greater density of fish than stocked before, as you may well know, and it is believed that it may cause operational difficulties in the treatment works. In 1983 there were more than 500 fish taken off the fish screening plates in the works, and a possibly worse situation is anticipated.

This season the intention is to very closely monitor the fish taken off the screens in order to assess the losses in relation to the stocking level. Therefore, the Authority is going to stock 1,000 rainbow trout this month and monitor their fate. Of course not only will some of the fish end up on the screens but also will be caught by you. Therefore we will need returns of all catches to enable us to analyse the fate of stock fish.

Enclosed are some fishing return forms, almost identical to those you've used before but pre-paid for your convenience. Just fold them up and put them in the post immediately after each fishing trip, please. The marking of this initial stocking of rainbow trout will be by cutting off the adipose fin. This is clearly shown in the diagram below and so please examine each fish carefully and record your observations on the return for that day.



Further stocking of fish will take place later on in the summer, possibly of greater numbers when the level of the reservoir drops. You will be informed nearer the time of the fish marking but in the meantime, please be vigilant, fill in a return every time you go to Stocks and don't forget to post it.

I hope you have a good season.

Yours sincerely,

J. E. Nott

J. E. Nott - Principal Fisheries Assistant

P.S. I'm sorry you did not get the return forms by the 15th but we had delays at the printers.

This matter is being dealt with by ____________

APPENDIX 3

North West Water

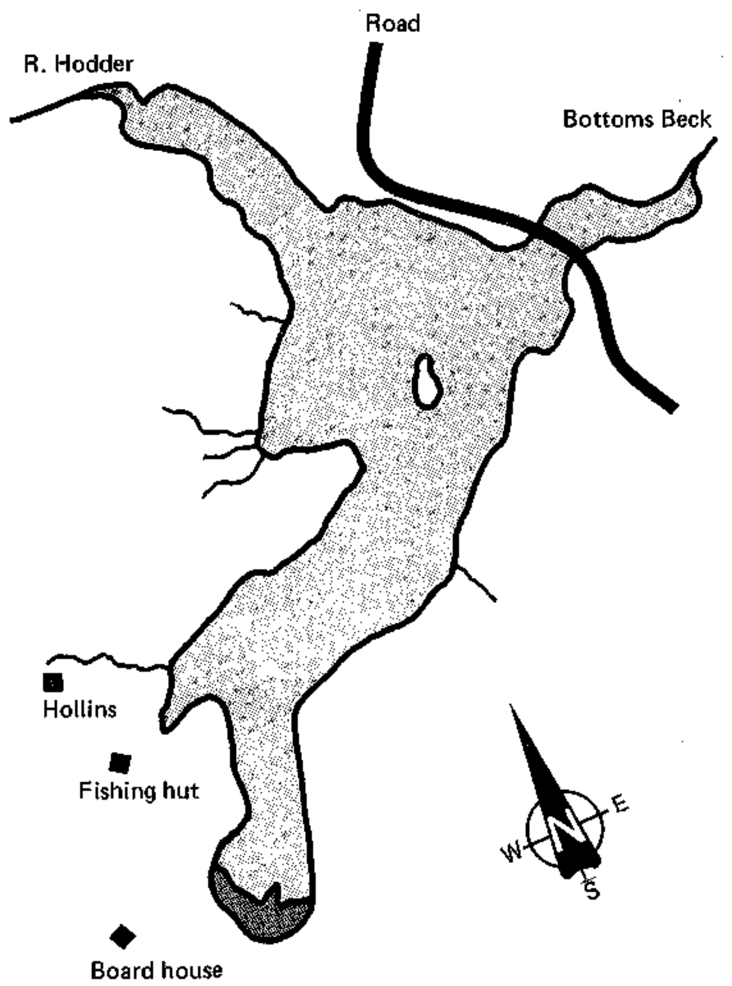
Stocks Angling Club

DIAGNOSTIC FISHING RETURN – STOCKS RESERVOIR

Name	Date	Times	Please tick box
		from ________	Fly [ ]
		to ________	Spinning [ ]
			Worm [ ]

Fish taken

	Brown/Rainbow	Brand, Marking or Tag	Length	Weight	Method	Condition
1						
2						
3						
4						
5						
6						



How many undersized fish returned [ ]

Weather conditions

General observations

Indicate general area fished on the map, irrespective of catch.

Indicate location of capture of marked fish.

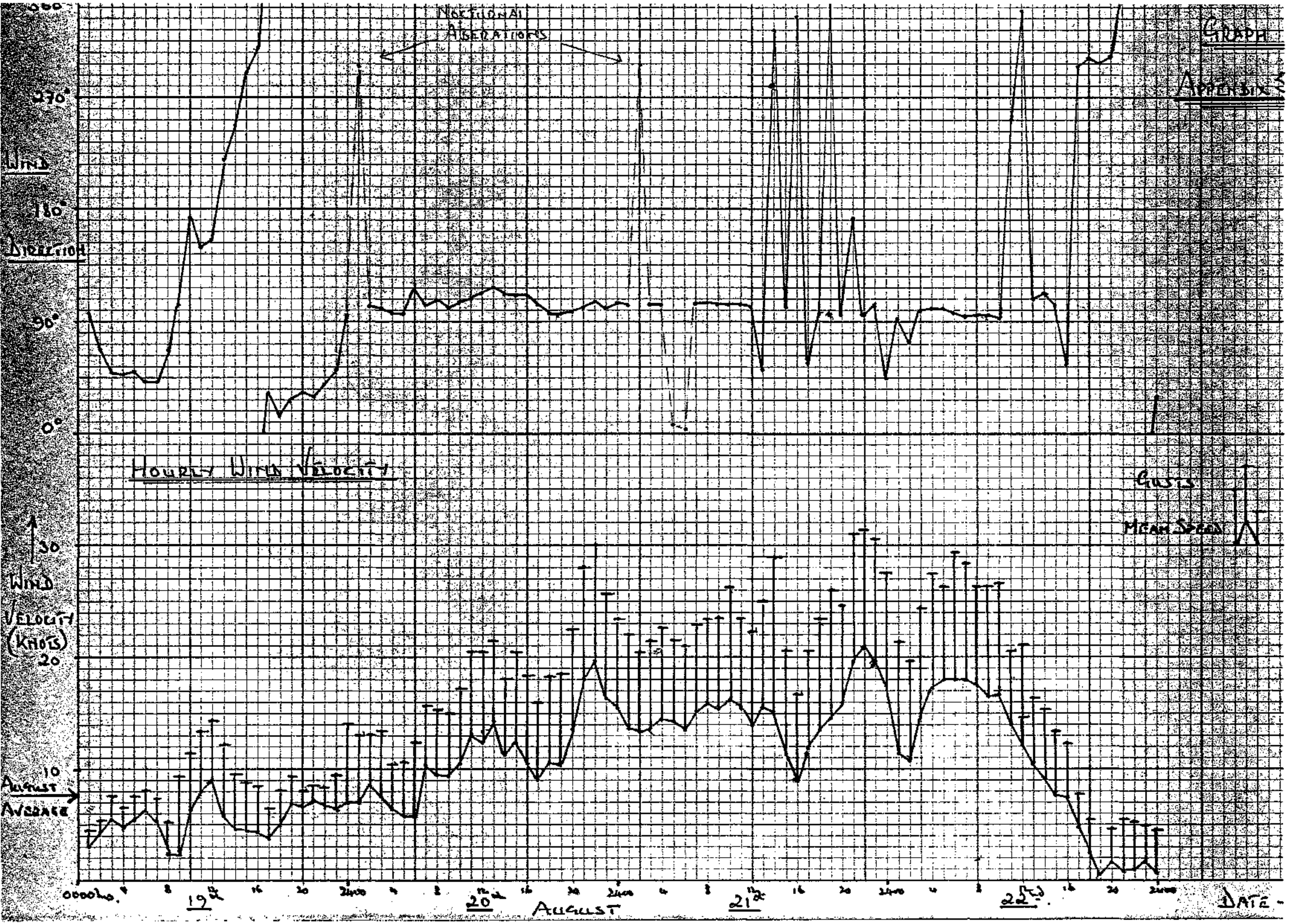
NOTES

A single **return** is required for every visit irrespective of catch.

Every fish is to be carefully examined for brand marking or tag and details given.

Please indicate wind direction [ ]

Please return completed returns by post to the Fisheries Officer immediately.



Graph
Appendix 3
Noctional Aberrations
Wind Direction
360°
270°
180°
90°
0°
Hourly Wind Velocity
Gusts
Mean Speed
Wind Velocity (Knots)
30
20
10
August Average
0000hrs.
4
8
12
16
20
2400
19th
20th
21st
22nd.
August
Date

WIND SPEED & DIRECTION - 1984 APPENDIX 5A.

Listed below are periods of above average wind conditions that have potentially exacerbated the loss of fish to the fish plates by adversely affecting the water quality.

Date	Duration (Hours)	Wi~~nd Speed~~	D~~irectio~~n
24th August	0900 - 1600	090°	12 knots
30th August to	0000		
1st September	- 1200	270°	15 knots
3rd September	0000 - 0900	270°	18 knots
8th September	0900 - 2400	270°	14 knots
9th September to	0000	220°	20 knots
11th September	- 1500	to 320°	to 15 knots

N.B. In addition to the plotted period of August 20th - 22nd with the increase in turbidity and fish loss, the period for September 9th to 11th is similarly correlated.

Average Wind Speeds in knots		1984	1983	1982
	July	7.1	5.5	7.0
	August	7.3	6.2	9.3
	Max. for year	14.1	15.2	12.3

ANGLERS RETURNS - STOCKS RESERVOIR - 1984

MONTH	TAKEABLE FISH			RETURNED FISH			Total Fish Caught	Fish Taken	Number of Visits	Takeable Catch/ Visit
	Brown Trout	Rainbow Trout		Brown Trout	Rainbow Trout	Not Named				
		Adipose Clip	No Record							
MARCH	34		5			11	50	39	10	3.90
APRIL	75	74	8	3	6	36	202	157	45	3.49
MAY	43	18	5	3	7	24	100	66	30	2.20
JUNE	47	20	4	5	2	21	99	71	29	2.45
JULY	38	23	15	13	-	17	106	76	28	2.71
AUGUST	35	153	44	20	12	51	315	232	51	4.55
SEPTEMBER	23	13	1	10	-	8	55	37	26	1.42
TOTALS	295	301	82	54	27	168	927	678	219	2.96

DIAGNOSTIC ANGLING - STOCKS RESERVOIR - 1983

MONTH	BROWN TROUT	RAINBOW TROUT	TOTAL FISH CAUGHT	NO. OF FISH RETURNED	NETT AVERAGE TAKE PER VISIT	NO. OF VISITS
MARCH	50	3	53	12	1.78	23
APRIL	92	3	95	41	1.32	41
MAY	113	2	115	51	1.77	36
JUNE	88	1	89	48	1.14	36
JULY	63	15	78	14	2.06	31
AUGUST	45	64	109	22	2.07	42
SEPT.	47	33	80	18	1.47	42
TOTALS	498	121	619	206	1.65	251

Appendix 7.

POPULATION ESTIMATE

Totals from Anglers Returns

Brown Trout	Rainbow Trout	Undersize fish Brown Trout	Undersize fish Rainbow Trout	Unspecified
295	301 marked 82 not specified	54	27	168

Total catch of 1984 stocked fish = 301

In 1983, 500 rainbow trout stocked of which 100 approx. caught

∴ 400 overwintered and 10% survived = 40

If all caught then 42 of the 82 unspecified R.T. were fin clipped = 42

Additionally approx. half of undersize R.T. could be clipped fish = 13

∴ Maximum recapture of fin clipped fish = 356

Thus proportion caught of 3,000 stocked = 11.87%

Assuming brown trout caught as easily as rainbow trout

∴ 295 is 11.87% of total in reservoir

∴ Total takeable B.T. = 2,485 fish @ 14 oz. each = 2,174 lbs.

Undersize brown trout = 54 + say ½ of unspecified undersize fish
= 54 + 84 = 138

if 11.87% is proportion taken total = 1163 fish
@ 5oz. average = 363 lbs.

Wild Rainbow Trout

Assume half of undersize previous years = 14

" half of unspecified undersize are R.T. = 84

∴ Total of 98 if 11.87% = 826 @ 8 oz. each 413 lbs.

2,950 lbs

If 356 stock fish caught then approx. 2644 alive in September

∴ 2644 fish at 14 oz. each = 2,644 lbs.

Total biomass of fish in Stocks Reservoir = 5,594 lbs.

APPENDIX 8.

Table of Estimated Density of Fish

at reducing areas for 1984

with estimated total fish biomass of 5,594 lbs.

Reservoir Full	343 acres	16.31 lbs/acre	(1.63 g/m^2)
Average summer area	210 acres	26.64 lbs/acre	(2.67 g/m^2)
Minimum estimated	100 acres	55.94 lbs/acre	(5.59 g/m^2)
Minimum 1984	62 acres	90.22 lbs/acre	(9.02 g/m^2)

STOCKS A.C. FISH STOCKING RECORD

APPENDIX 9.

Date	Species	Nos.	Size	Comments
24th July '84	Trout	2,000	10"-12"	Adipose fin clipped
28th March '84	Rainbow Trout	1,000	10"-12"	" " "
June 1983	Rainbow Trout	17,000	3"-4"	
July 1983	Brown Trout	5,000	Fingerlings	Bottoms Beck
July 1983	Rainbow Trout	500	10"-12"	-
September 1982	Brown Trout	2,000	7"-8"	-
July 1982	Rainbow Trout	200	10"-13"	-
February 1982	Rainbow Trout	200 lbs.	Mixed	-
February 1982	Brown Trout	200	11"	-
August 1981	Brown Trout	200	13"-14"	-
August 1981	Brown Trout	2,000	7"-8"	-
March 1981	Rainbow Trout	559	9"-12"	-
1980	Rainbow Trout	150 lbs.	12"-14"	-
1979	Rainbow Trout	228 lbs.	9"-13"	-
1978	Brown Trout	700	9"-11"	-
1977	Brown Trout	542	9"-11"	-
1977	Rainbow Trout	1,000	9"-11"	-

STOMACH ANALYSIS

STOCKS RESERVOIR TROUT

sampled between 15.9.84. & 25.10.84.

Length (mm)	Stomach Contents
245	Empty
240	Empty
235	Remains of insects (including recognisable chironomid pupae) and remains of Cladoceran ephippia.
230	One small dytiscid beetle.
215	Full of remains of insects, various types of adult flies, chiromonid types, small wasp like flies, a spider and remains of Cladoceran ephippia.
210	Six adult chironomids.
200	Virtually empty, apart from remains of a few Cladoceran ephippia.
175	Unrecognisable insect remains and a few Cladoceran ephippia.
165	Empty.
140	A few remains of Cladocera.
130	One dytiscid beetle, a few remains of Cladocera.
125	Full of freshly eaten Cladocera.
No. 8	The sample also contained eight recognisable trout, within the above size range but which had decomposed or been damaged such that examination of stomach contents was impossible.
No. 28	In addition 28 small bullheads were present.

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ACKNOWLEDGMENT

Sincere appreciation and thanks to Mr. G. Keen, Plant Superintendent at Hodder Water Treatment Works, Stocks Reservoir, for his patient assistance in providing data for this investigation.

Additionally to his operatives for their work in collecting and recording the fish on the fish plates.

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